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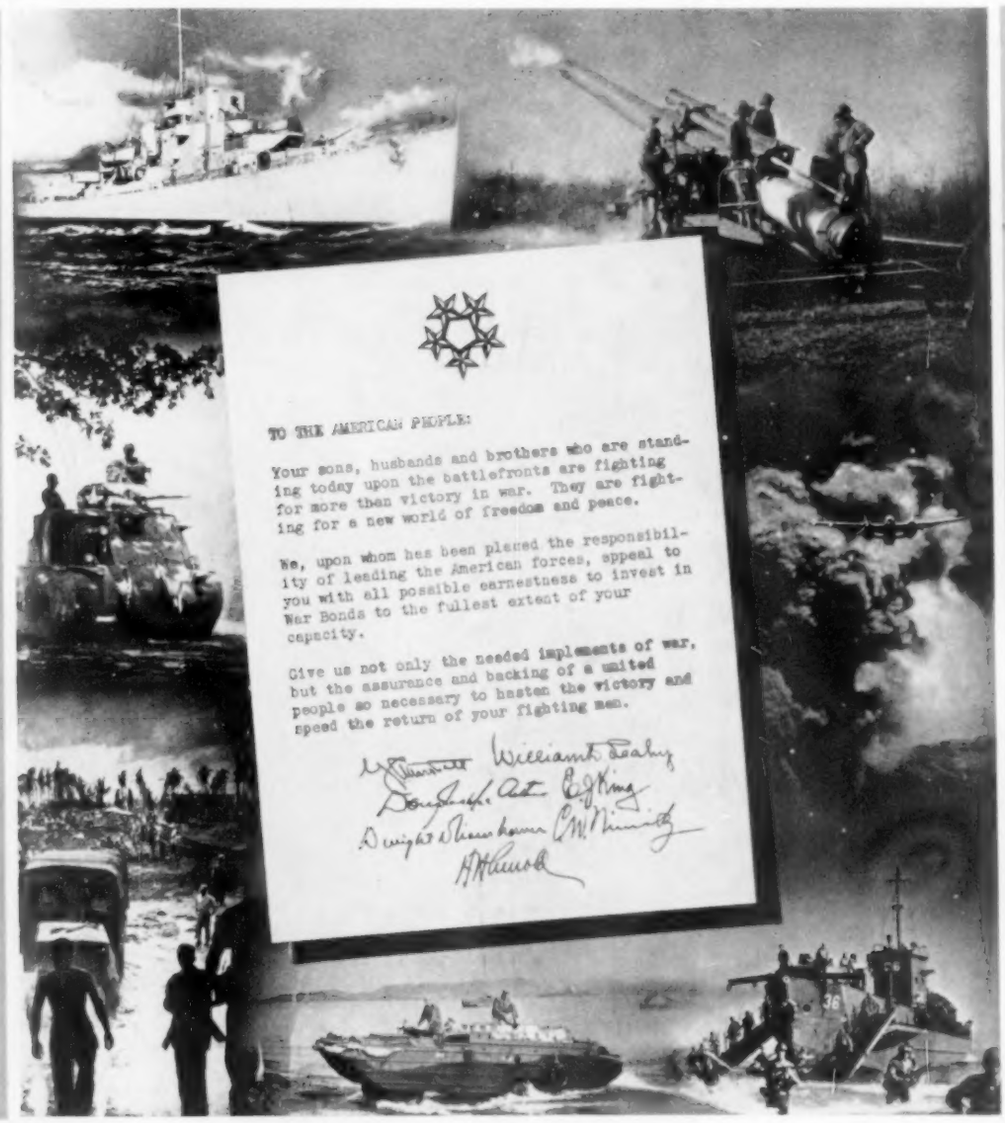
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The Journal of the American Welding Society

Published for the Advancement of the Science and Art of Welding

W. SPRARAGEN, Editor

JUNE, 1945

VOLUME 24 . NUMBER 6

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A Letter From Our 5-Star Admirals and Generals.

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Subscriptions $5.00 per year in United States and possessions; Foreign Countries $7.00. Single copies, non-members $.75; Special issues October and December $1.00; members 50 cents

Entered as second-class matter January 15, 1932, at the post-office at Easton, Pa., under the act of March 3, 1879.

PUBLICATION OFFICE
20th & Northampton Streets, Easton, Pa.

EDITORIAL AND GENERAL OFFICES
33 West 39th St., New York 18, N. Y.

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The Journal of
The American Welding Society
VOLUME 24 · NUMBER 6 · JUNE, 1945

An Analysis and Comparison of Various Resistance Welding Systems

By R. L. Longini*

THERE are a number of systems for producing resistance welds by taking power directly from the line without any energy storage. These different systems vary in their effect on the power lines, certain of their welding characteristics and their costs. It is the purpose of this article to compare all aspects of the non-energy storage systems.

Two important characteristics of welders are their power requirement and their power factor. Figure 1 (*a*) shows power factor and how it is related to heat producing and reactive powers.

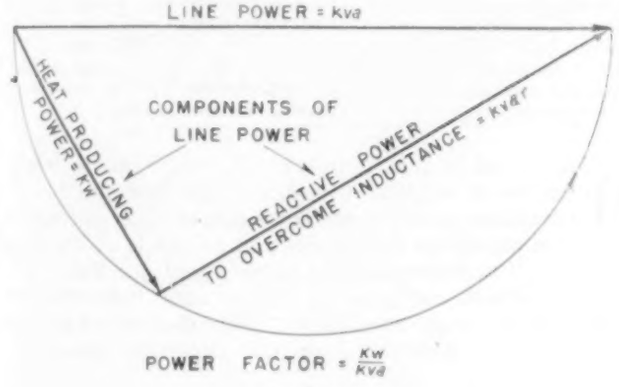
LINE POWER = Kva
HEAT PRODUCING POWER = Kw
COMPONENTS OF LINE POWER
REACTIVE POWER TO OVERCOME INDUCTANCE = Kvar
POWER FACTOR = Kw/Kva

Fig. 1 (*a*)

Power factor is the ratio of the heat-producing power (kw.) to the line power (kva.), as shown in the sketch.

A welding machine designed for a certain type of welding operation must have several qualifications. First, it must be capable of delivering enough kilowatts to the electrodes to produce the desired weld. Second, the mechanical constructions must permit the work to be placed between the electrodes conveniently. This second requirement determines the shape of the secondary loop and therefore its inductance. Thus the reactive power is determined and the right triangle of Fig. 1 (*a*) is fixed.

In machines with power factors below 0.5, that is, where the reactive power is large and the machine has a large inductive electrode throat, the current is largely determined by the inductance so that a slight variation of resistance has practically no effect on the current. Machines with power factors of 0.8 or over are more dependent on stable work resistance than are low power factor machines.

Line voltage drop results primarily from reactive power because of the nature of the distribution systems. Figure 1 (*b*) shows the relative voltage drop on low-voltage systems as a function of load power factor to make a given weld. The actual voltage drop will, of course, depend on the line regulation and the size of the welder in question. Welders operated on 2300-v. lines do not normally produce nearly as great a relative voltage drop at low power factors as do 230- or 460-v. machines having the same power requirements.

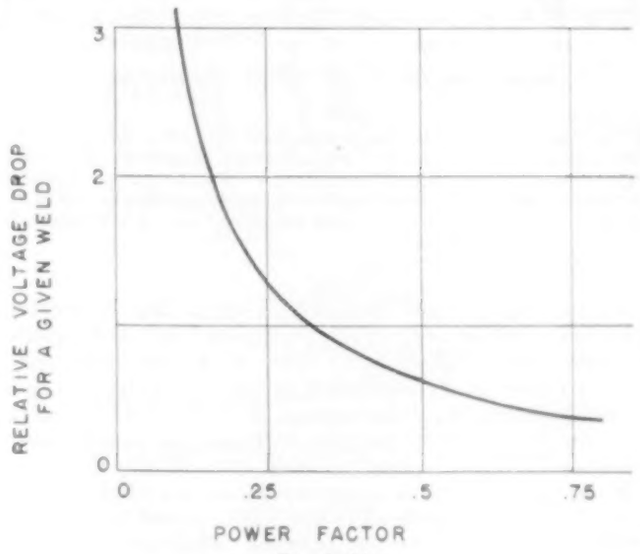

Fig. 1 (*b*)

The line voltage drop is dependent on the power factor of the load and on the actual energy used in the weld. The curve shows the relationship between voltage drop and power factor for a given kw. power required at the weld.

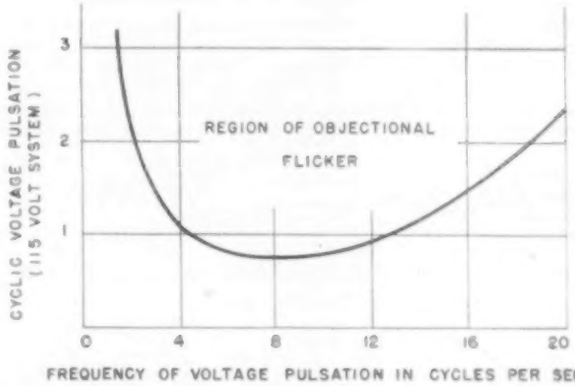

Fig. 2

Welder operation results in pulsation of voltage which produces light flicker. The physiology of the eye is such that the frequency of pulsation is a determining factor in visual perception of flicker.

* Resistance Welding Engineering Dept., Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

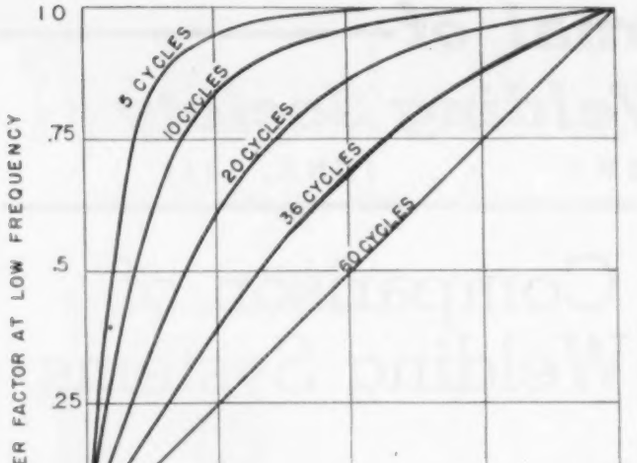

Fig. 3

The power factor of various transformer secondary throats varies with frequency. Power factor is a function of frequency and of the mechanical structure of the throat of the welding machine. Various mechanical structures are represented by their power factor at 60 cycles. This power factor is for the secondary circuit only, and not that of a complete system.

Though the actual line voltage drop due to welder operation may be very small, it may, nevertheless, result in objectionable light flicker. The eye is extremely sensitive to flicker if its frequency is in a particular range. Figure 2 shows the objectionable voltage variation as a function of frequency. If the voltage drop is very bad, power and control equipment may even be affected.

If the line voltage drop caused by an a-c single-phase, 60-cycle welding machine is too great, power factor correction may be used to improve conditions. Power factor correction very greatly reduces the reactive power requirements and brings the demand down almost to the kilowatts required to make the weld. Power factor correction on individual machines is not always the most economical solution. It may be more economical to increase the size of feeder lines and distribution equipment or to operate the welder on 2300 v. directly from a well-regulated distribution network. In large plants where there are many welders, it may be found desirable to correct the entire plant power factor rather than individual machines as, by so doing, use can be made of the fact that not all machines will be operating at one time.

Two methods are used for power factor correction on individual a-c type machines. The reactive power can be completely eliminated by use of series capacitors.

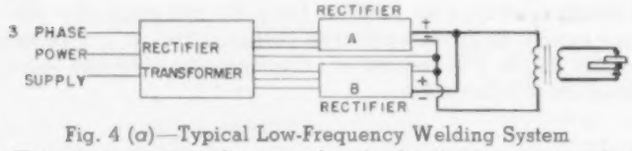

Fig. 4 (*a*)—Typical Low-Frequency Welding System

This system consists of two rectifiers back to back, operating from one power transformer. Only one rectifier operates at a time, operating for $^1/_2$ of a desired low-frequency cycle. The rectifiers, in turn, apply voltage of opposite polarity to the welding transformer. Thus, for 12-cycle operation, each rectifier, in turn, would operate for $^1/_{24}$ sec. Power is drawn from the three lines of the three-phase system.

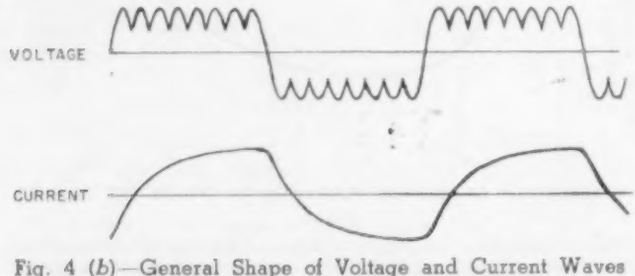

Fig. 4 (*b*)—General Shape of Voltage and Current Waves from a Typical Low-Frequency Welding System

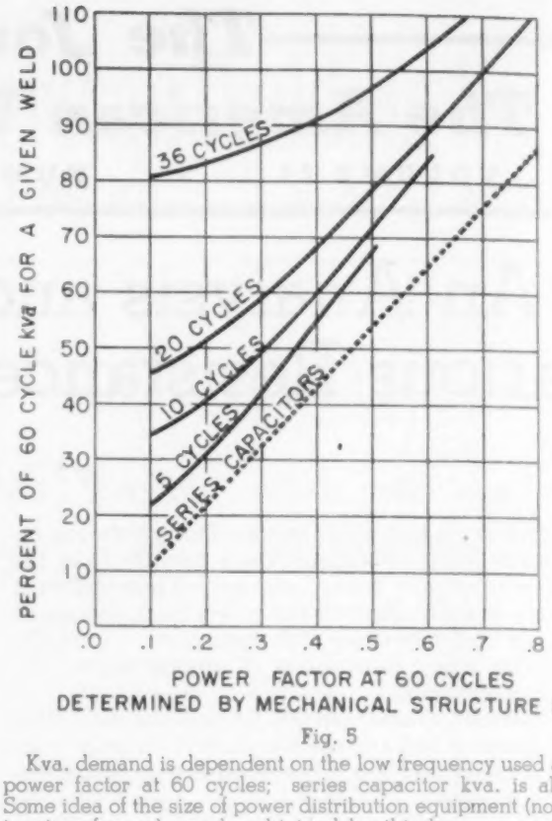

Fig. 5

Kva. demand is dependent on the low frequency used and on the power factor at 60 cycles; series capacitor kva. is also shown. Some idea of the size of power distribution equipment (not the welding transformer) can be obtained by this kva. comparison. The three-phase to single-phase systems (low frequency) divide the kva. demand among the three phases. The series capacitor system, being single phase, draws its power from two lines only. The curves shown for the low-frequency systems are for ideal control. Ordinary controls now available have certain faults at low power factor which raise the kva. demand above these curves.

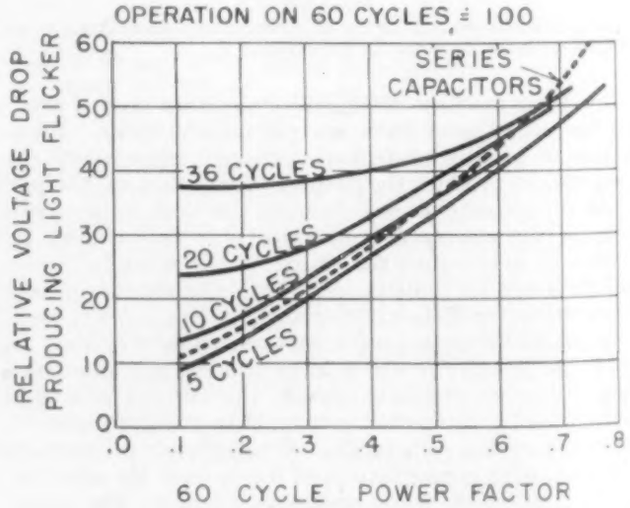

Fig. 6

The curves show how the voltage drop is reduced by power factor correction systems. By coordinating these curves with that of Fig. 2 it is possible to determine whether light flicker can be eliminated. These curves are for an ideal control system. Ordinary controls for low-frequency systems now available have certain faults which at low power factors, greatly increase the voltage drop.

The reactive power can be greatly reduced by operating the welder at lower frequency, for example, 10 cycles.

Because of the great variety of electrode throat shapes, work done, size of conductors, etc., it is impractical here to bring in each of these factors in the discussion of kilovolt-ampere reduction. Each combination of mechanical structure and work will, however, determine a welder power factor if used on a simple single-phase, 60-cycle system. This power factor will be, for our purposes, sufficient to designate the various combinations. We will frequently refer to 60-cycle power factor when referring to systems which are never operated on 60 cycles. We will, in this case, mean only the mechanical structure-work combination would give this welder power factor if operated on 60 cycles. Figure 3 shows how the power factor of various transformer secondary throats varies with frequency. Note that this is the basic power factor of the secondary circuit only and not that of a complete system.

The low frequency system, in addition to raising the power factor, distributes the load among the three phases. Thus, instead of a relatively large voltage fluctuation on only two lines, this system gives a smaller voltage fluctuation on all three lines as compared with an uncorrected a-c single-phase system.

The over-all utilization (ratio of kilovolt-amperes delivered to the throat to the kilovolt-ampere demand on the power system) of systems varies. For low frequency systems it may be from 70 to 85%, and for the series capacitor systems it will be from 90 to 95%. The low frequency systems now in use are most easily described by a schematic diagram with voltage and current waves (Fig. 4) for one of them. Individual systems may differ from this in detail, but they are fundamentally the same.

Both the series capacitor and low-frequency systems are used for reducing the kilovolt-ampere demand on the line. It is therefore desirable to see just how the kilovolt-amperes are reduced by going to these systems. The improvement will, of course, depend on just how large a portion of the load was reactive in the first place. This will be determined by the mechanical structure of the throat and the type of work to be done. Figure 5 shows how the kilovolt-ampere demand to make a given weld is dependent on the low frequency used and on the power factor at 60 cycles. Series capacitor kilovolt-amperes are also shown.

One of the major purposes of using a power factor correction system is the reduction of light flicker. The three-phase to single-phase systems reduce the voltage

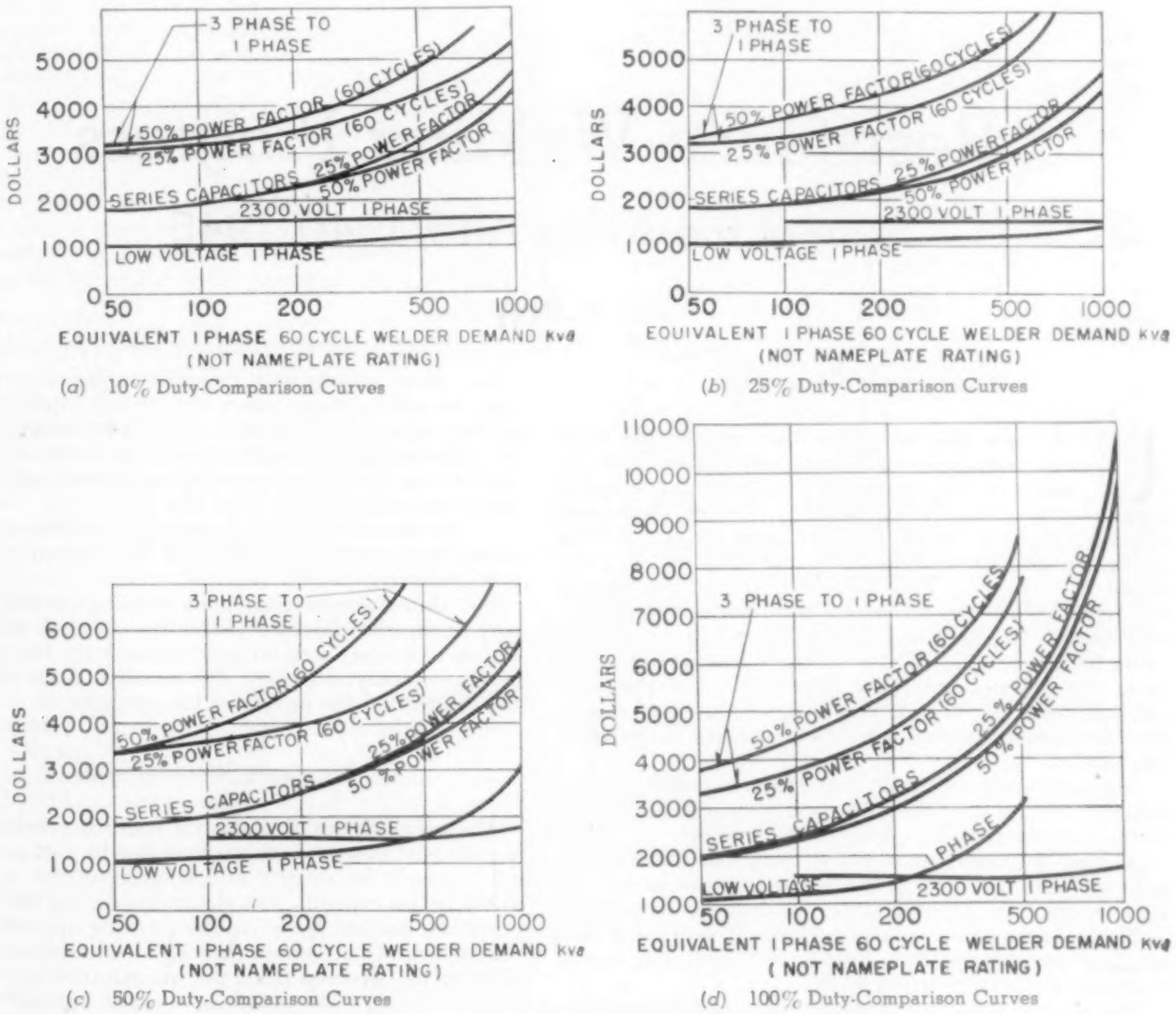
3 PHASE TO 1 PHASE
50% POWER FACTOR (60 CYCLES)
25% POWER FACTOR (60 CYCLES)
SERIES CAPACITORS 25% POWER FACTOR
50% POWER FACTOR
2300 VOLT 1 PHASE
LOW VOLTAGE 1 PHASE
DOLLARS
EQUIVALENT 1 PHASE 60 CYCLE WELDER DEMAND kva
(NOT NAMEPLATE RATING)
(a) 10% Duty-Comparison Curves
(b) 25% Duty-Comparison Curves
(c) 50% Duty-Comparison Curves
(d) 100% Duty-Comparison Curves

Fig. 7.—Cost of Control Equipment

A rapid approximation for the cost of any system and a comparison between systems can be obtained by use of these curves. These curves are for synchronous control on all systems. Other types of control would modify the curves only slightly.

drop on two lines even at high power factors due to the division of load among the three phases. The series capacitor system, however, does a better job of power factor correction. When 60-cycle power factor is low and much is to be gained by good power factor correction, the series capacitor system, in spite of its being single phase, is as good as the low-frequency system. Figure 6 shows the voltage drop producing flicker for both the low-frequency and series capacitor system and compares them to an uncorrected 60-cycle system. As was previously mentioned, the three-phase to single-phase low-frequency system results in a voltage drop on all three lines, whereas the series capacitor drop is on only two lines.

The cost of the equipment will be a deciding factor in the selection of the welder in many cases. It is, in general, preferable to use the single-phase system without power factor correction wherever possible. If the installation is large, it will probably be desirable to operate from a 2300-v. line rather than a 230- or 460-v. line. In general, 2300-v. systems have better voltage regulation. When power factor correction for an entire plant is being figured, the individual machines will probably be operated as 60-cycle, single-phase welders.

A graphical representation of the cost of various systems is shown in Fig. 7. The cost depends on the type of control, duty cycle, power factor of welder transformer and load and power supply voltages. The duty cycle is approximately equal to the ratio of time for one "on" period to time for one "on" plus one "off" period. The cost for single-phase uncorrected systems is independent of power factor, for a given kilovolt-ampere. Series capacitor and three-phase to single-phase systems will, however, depend on the uncorrected power factor.

Conclusions

There may possibly be some advantages in the use of one system over another for welding on metallurgical grounds. On purely electrical grounds however, we can draw the following conclusions:

1. A reduction of light flicker can be obtained by operating directly from 2300-v. lines instead of on low-voltage distribution systems.
2. Series capacitor systems are the least expensive means for power factor correction on individual machines either for reduction of kilovolt-amperes or light flicker, but do require adjustment if the welding loop is varied, and perfect power factor correction is desired.
3. Voltage pulsations produced by low frequency operation fall in the frequency range of greatest eye sensitivity.

Resistance Welding Progress

State of the Art in 1915, 1940, 1945

By J. W. Meadowcroft*

Resistance Welding 1915

UP TO this time the application of resistance welding (butt, spot and seam) had developed in the hands of shop men who were more interested in speed of production than in quality. In fact, the process appeared to be so simple that the users of the machines naturally thought that they knew all there was to know about the subject. Thus the development was largely the result of mechanical ingenuity to the end of production speed. Not only was this ingenuity of a remarkable order but the results were, on the whole, surprisingly good from the standpoint of the objective. Unfortunately available methods of test were very meager and unsatisfactory as were the means for control of the major welding factors.

Although some attention was given to quality, many failures occurred. The correction was naturally more welds, in some cases supplemented by rivets.

A mere enumeration of the devices and methods developed prior to 1915 is far beyond the scope of this review, but a few significant ones may be mentioned.

Flash welding was rapidly replacing the original butt welding process and had already increased the size of weldable sections by many times.

But seam welding in the manufacture of thin wall tubing had already been in use for over 10 years but in a very restricted field and not well developed for broader applications.

Lap seam welding with the aid of roller electrodes had been known for many years but its development except for very thin stock had been practically blocked by lack of understanding of the phenomena involved. It was not until a later date that the periodic interruption of the current was employed.

In the case of spot and projection welding enormous strides had already been made in the mechanical evolution of the art.

For thin-gage material poke welding played a large part in the manufacture of the first Allsteel automobile bodies and was later largely replaced by bar welding, which not only improved the quality of the weld but also eliminated the fatigue of the operator.

Resistance Welding 1940

The rapid strides in the art of resistance welding during the past twenty-five years are due in part to increasing demands for quality and in part to new apparatus available for control. Developments during the last five years are marked by a rapidly growing appreciation of the importance of a more thorough understanding of the phenomena involved from the quantitative or scientific point of view. The result is a rapid accumulation of accurate knowledge of the relation of the quality of a weld to the current, time and pressure for the various gages and kinds of material. The appreciation of a necessity for more accurate time control has resulted in the development of vastly superior timing devices,

* Asst. Works Manager, Edward G. Budd Manufacturing Co., Philadelphia, Pa.

mechanical, electronic and combinations of both. In some critical cases recorders are used which give a graphic record of the heating power of the current for every weld.

Much research work is in progress involving a careful study of the distribution of heat in the weld zone with particular relation to the electrical and thermal resistivity of metal and the contact resistance as related to the pressure and temperature. Residual stresses resulting from thermal gradients, are more or less damaging.

Where very heavy currents are necessary for spot welding heavy gages of materials it has been found advantageous to interrupt the current one or more times in order to give time for the electrode to cool.

In seam welding a radical change is taking place which involves longer interruptions of current between shots. This is the direct result of the more scientific method of attack mentioned above.

The percussion welding method which involves either the discharge of a static condenser or a magnetic field has been applied very recently to spot welding by the discharge of a condenser through the primary circuit of a welding transformer, also by breaking a direct current in the primary of the welding transformer. Both of these methods are definitely superior where very rapid heating is desired; for example, in the case of thin material or material of high electrical and thermal conductivity. The increase in the use of these methods in certain fields will be as rapid as the cost of change permits.

The development of butt seam welding in the manufacture of steel tubing or pipe has been very rapid and constitutes a new industry of considerable magnitude.

In general, there has been a greater increase in the intelligent application of resistance welding to critical structures in the past ten years than throughout its previous history. The speed with which the scientific methods have been applied to resistance welding problems is due in considerable part to the work of the Welding Research Committee of the AMERICAN WELDING SOCIETY.

1945—Advances in the Resistance Welding Art During the Past Five Years

Most of these advances have been in the way of refinements in existing apparatus and technique, some of which are mentioned below.

However, there was one very important and long-standing problem which was solved for the first time, namely, the successful spot welding of high-carbon or more hardenable steels. This job had never been done before without leaving the weld zone in a very brittle state. The process consists essentially in tempering the welding zone, in the welding machine as a part of the welding process. One or more shots of current are applied after the original weld has partly cooled. The timing and intensity of these additional shots, which are automatically applied, are critical.

The need for such a weld was thoroughly appreciated nearly twenty-five years ago and many efforts were made to produce it. These efforts failed because they were along empirical lines of cut-and-try where the number of possible combinations of off-intervals with the current intensity and on-intervals is practically infinite, when not guided by sound knowledge of the cooling rates as related to the desired metallurgical transformations.

Thus the opening up of a new and important field of application for spot welding was made possible only by the application of scientific knowledge well beyond that available to most welding engineers and metallurgists.

Another important but less spectacular advance is in connection with voltage or current control. Since there is no simple instrument available for indicating the current delivered to a spot-welding circuit, it is obviously important to know that the welding current is always the same for a particular job. Unfortunately, in the case of heavy a-c spot welding the current is so large that the drop of voltage on the feeder is often considerable. This would be all right if it were always the same, but there may be fifteen or twenty welding machines on the same feeder and when two or more of these strike at once the additional voltage drop may be such as to yield a seriously under-strength weld, unless the feeder is designed with more care and knowledge of probabilities than is ordinarily available.

Two electronic control devices have been developed, both of which operate very rapidly, although the final correction is not complete until after the expiration of one or two cycles of a 60-cycle current. One of these is called a voltage compensator and maintains a constant voltage on the primary side of the welding transformer. The other is called a current regulator and maintains a constant current. Both are satisfactory with a duration of current flow of five cycles or more but not so good for one or two cycles.

Another but earlier check is known as the ampere squared second recorder which gives a record of this item for every weld. If the I^2t is outside of a certain safe operating range due to some unusual voltage drop, an audible or visible signal is given to indicate that that weld should be made over again.

All of these three devices together with greatly improved feeder designs have resulted in much greater dependability of each individual weld. This has been an evolutionary process forced upon the industry by much unsatisfactory spot welding in the early days.

Much is yet to be desired in the flash-welding field, in this same direction of quantitative knowledge and control. Some quantitative research work has already been done but there is need for much more.

Considerable work in this same direction of refinement has been carried out in connection with the fabrication of resistance welding tubing, as well as in connection with its testing.

The striking part of this whole picture is the rapidly increasing use of more refined or scientific methods of analysis and of measurement. In other words, the gap between the industrial application of this art and the scientific knowledge of the complex phenomena involved, is gradually being closed.

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Application and Development of Modern Heavy-Coated Arc-Welding Electrodes*

By D. C. Smith and W. G. Rinehart†

WHEN the United States became involved in World War II the desperate need for large quantities of war material forced manufacturers to use welding more than ever before as a means of fabrication. Electrode producers, in turn, had to increase production, improve, modify and develop new products to meet the ever-increasing demand of industry for better welding electrodes.

Furthermore, electrodes capable of producing quality weld metal with satisfactory performance when used on a.-c. transformer sets were required, and in many cases demanded by the fabricator, especially those just changing to welding processes. A large variation in sizes of electrodes was also needed. Today coated electrodes of from $^1/_{32}$ to $^1/_2$ in. in diameter are being used to weld material varying from a few thousandths of an inch to many inches in thickness. As a consequence, industry is successfully welding practically all of the commercial metals and alloys; even magnesium which was considered impossible to arc weld until recently is now being welded by the "heli-arc" process. Today the attitude is that any structural metal or alloy can be welded given the proper electrode and welding procedure. This ability to arc weld so many diverse materials and structures has been made possible by the improvement of old and the development of new electrodes. These improvements and developments of electrodes are a result of better knowledge and application of the properties of coating materials.

Influence of Coating Materials on the Arc Energy Distribution

The nature and extent of the influence of coating materials on the properties of arc-welding electrodes is of paramount importance to the electrode designer, and one receiving a great deal of study. A review of the literature indicates, however, that many conclusions reached by independent investigators on the action of materials in the arc are not in agreement. Since empirical methods largely predominate in the procedures followed in these fields of investigations, this nonagreement is to be expected.

The influence of any new compound or element or changes in the amount of a compound or element already present is often affected by the other materials in the coating. For example, the influence of ferromanganese on the welding properties of an E6020 electrode is greatly affected by the amount of iron oxide or other oxidizing materials present in the coating. Thus the conclusions reached by one investigator studying the influence of a compound may be quite different from another studying the effect of the same compound on another type of coating. Some better means of quantitatively measuring the influence of coating material on the arc is desired by the electrode manufacturer.

Alexander[1] found that the distribution of total energy between anode and cathode is affected by the coating materials. The influence of a few of the common coating materials used in the energy distribution study of Alexander's is shown in Table 1.

Table 1—Influence of Coating Materials on the Energy Distribution of the Arc Between Cathode and Anode for an Iron—Iron Electrode System. (Taken from Alexander's Data[1])

Coating Materials	Cathode Energy, %	Anode Energy, %
Na_2O	48.2	51.8
TiO_2	48.9	51.1
CaO	49.3	50.7
$Na_2Si_4O_9$	51.8	48.2
None (Fe-Fe)	52.3	47.7
MgO	53.2	46.8
$Na_2B_4O_7{\cdot}10H_2O$	53.2	46.8
Al_2O_3	55.6	44.4
$CaMg_2(SiO_3)_4$	55.8	44.2
$NaFe(SiO_2){\cdot}FeSiO_3$	58.5	41.5

While an investigation of this nature has not been conducted in this laboratory, our observations partly confirm these results. It appears, however, that the effect of any one constituent upon the energy distribution may be affected by the other materials, a factor not indicated by Alexander's data.

It appears from the data that any element or compound tending to bring an equal balance of arc energy between anode and cathode would improve the a.-c. welding properties of the electrode; also that compounds or elements which shift the balance of energy toward the anode could be used to increase the penetrating properties or affect the arc characteristics on reverse polarity in some other beneficial way. Likewise, those that shift the balance to the cathode could be used to produce similar penetrating properties or arc characteristics for straight polarity welding.

It is a common practice of electrode designers to use coating materials that are arc stabilizers for a.-c. electrodes. Thus we would expect to find that they produce a better energy balance between cathode and anode. Unfortunately, there have not been sufficient data published along this line, known to the authors, to confirm or disprove this assumption but it is our experience that

* Presented at the Twenty-Fifth Annual Meeting, A.W.S., Cleveland, Ohio, Oct. 16 to 19, 1944.

† Chief Metallurgist and Research Metallurgist, Harnischfeger Corp., Electrode Division, Milwaukee, Wis.

the best arc-stabilizing materials such as titanium and potassium compounds are generally found in the modern a.-c. heavily coated electrodes.

The Welding Slag

Just as the steel maker uses slag to control the quality of his steel, so must the electrode designer use the slag formed by the burning electrode to control the quality and shape of the weld deposit. The quality of the weld deposit depends in part upon the fluxing action of the slag to clean the molten metal of oxides formed during the transfer through the arc and to the protective blanket formed over the weld metal while cooling. The amount, density, freezing point and viscosity range of the slag help shape the bead. The composition of the slag is dependent upon the composition of the coating and is varied by changing the proportions or kinds of coating material.

Formulating an electrode coating that will produce the right freezing point and viscosity range of the resultant slag is one of the major problems of the electrode designer. Metals and crystalline solids have a sharp melting point passing from solid to liquid within very narrow temperature limits, while slags act like amorphous materials and do not have a definite melting point but soften, become mobile and finally liquid over a wide temperature range. While there is no correlation among the freezing point, viscosity range and surface tension, yet they must be considered together and constitute what the welder calls "fluidity."

For vertical and overhead welding a fluid slag with a short viscosity range is needed. The slag must be fluid enough to clean the molten metal and scarves along the joint but freeze close enough to the arc to hold the metal in place as the welding progresses. A slag that is too fluid will flow away from the molten pool allowing the metal to "sag" or "drip," forming an uneven surface. Sluggish slags do not clean properly and may become entrapped in the weld deposit. Irregular surfaces and improper fusion may also result from sluggish slags. Downhand welding permits the use of more fluid slags with a greater viscosity range and the resultant deposit is of better quality.

Unpublished data of the R. T. Vanderbilt Co. show the freezing point and viscosity range of several commercial electrode coatings to be as follows:

Electrode	Freezing Point, ° F.	Viscosity Range, ° F.
E6010	1463–2345	72–477
E6012	2282–2417	81–287
E6020	1940–2138	81–315

The authors are unaware of any data on the freezing point and viscosity range of the resultant slags. However, Herty and co-workers[2] have measured the viscosity range of several steel-making slags and their results show that very basic slags are more sensitive to temperature changes than weakly basic slags. This change of viscosity with temperature makes it possible to design coated electrodes for welding in all positions.

To point out some of the recent developments that have been made in modern heavy-coated electrodes it will be necessary to review some of the information given in the literature as each electrode is considered. Since it is beyond the scope of this paper to review the developments in all types of electrodes only the three fundamental groups and a new ferritic type that is now in demand and which it is hoped will overcome some of the defects of the older electrodes will be reviewed.

The three fundamental groups of heavy-coated arc-welding electrodes are classified by the A.W.S.-A.S.T.M. as shown in Table 2. The properties of the new ferritic electrode are shown in Table 5.

There has not been any significant change in the core wire used in making coated electrodes during the past few years. It is still a rimmed steel of 0.10 to 0.15% carbon, 0.40 to 0.60% manganese. A uniform core surrounded by an even rim is very important to insure a concentric burning electrode, whereas an irregular or incomplete rim causes poor arc characteristics.

Group I—E6010 and E6011

The majority of electrodes used today are of the E6010 and E6011 types. They can readily be recognized by their nearly straight fillet profile and deep penetration as shown in Figs. 1 and 2 and Table 3. The

Table 2—Characteristics of the Three Fundamental Electrode Groups

Description	Group I		Group II		Group III	
A.W.S.-A.S.T.M. Classification No.	E6010	E6011	E6012	E6013	E6020	E6030
Welding position	All	All	All	All	Flat and Horizontal	Flat
Best operating currents	DC-R	AC or DC-R or S	DC-S or AC	AC or DC-S or R	DC or AC S-H fillets R-flat	DC-R or AC
Fillet profile	Flat	Flat	Convex	Convex	Concave	Concave
X-ray quality* (holes/in.³ of weld)	2–5	1–3	15–20	3–6	0–2	0–2
Penetration (approx.)†	2.0	1.3	1.2	0.5	1.5	2.3
Spatter (approx. %)	13	13	7	7	10	10
Efficiency (approx. %)	76	74	79	75	67	66
Physical properties*						
Yield point, psi.	57,000	57,000	63,000	59,000	58,000	58,000
Tensile strength, psi.	68,000	68,000	76,000	70,000	66,000	66,000
% Elongation in 2 in.	25	26	18	20	28	28
Impact-Izod (ft.-lb.)	87	64	36	40	64	64
Distinguishing coating constituent	Cellulose		Titania		Iron oxides	

* X-ray quality and physical property values are typical of what may be expected of these electrodes when recommended welding procedures and standard methods of testing are used.

† Penetration values obtained under condition described in Table 3.

DC = direct current. S = straight polarity. R = reverse polarity. AC = alternating current.

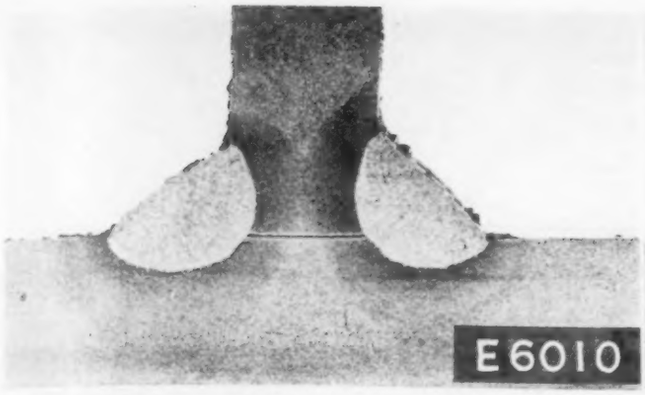

Fig. 1—Fillet Profile of E6010 Made with $^5/_{32}$-In. Electrode, 160 Amp., 26 V., Reverse Polarity. 2 ×

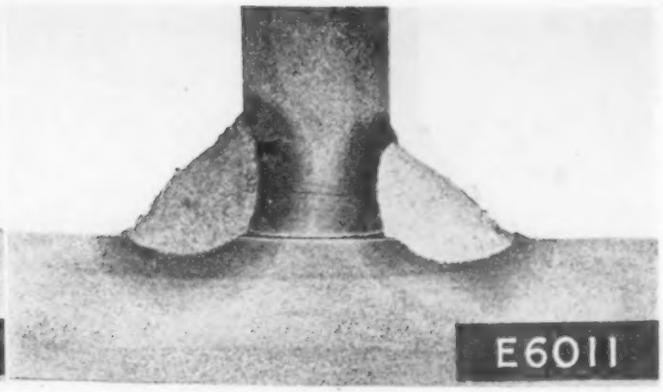

Fig. 2—Fillet Profile of E6011 Made with $^5/_{32}$-In. Electrode, 160 Amp., 26 V., A. C. 2 ×

E6011 primarily developed for a.-c. welding has only been perfected sufficiently well within the last two years to take an important place in the industry. The E6010 is the electrode most universally used for all classes of welding and is approved in nearly all specifications for mild steel electrodes.

Table 3—Penetration of Fillet Welds Manually Deposited in the Flat Position on $^3/_8$-In. 1020 Steel with $^5/_{32}$-In. Electrodes

A.W.S.-A.S.T.M. Classification No.	Current and Polarity	Amp.	Volts	Penetration, Mm.
E6010	D.-C. Reverse	160	26	2.0
E6011	A.-C.	160	26	1.3
E6012	D.-C. Straight	170	22	1.2
E6013	A.-C.	170	20	0.5
E6020	D.-C. Straight	175	33	1.9
E6020	D.-C. Reverse	175	33	2.3
NRC-2A	D.-C. Reverse	195	26	1.3

The electrodes of Group I, Table 2, produce a high-quality weld deposit in all positions. To produce these properties of good weldability and weld quality when used in all positions a coating is required that will:

1. Give a thin, low-density, fast-freezing slag.
2. Produce a reducing atmosphere around the arc which will exclude the oxygen and nitrogen of the air, thus augmenting the slag which of itself is insufficient to give the necessary protection.
3. Regulate the weld deposit through the viscosity and surface tension of its slag, thus enabling it to freeze at the desired rate.
4. Give the desired penetration.
5. Regulate electrical characteristics of the arc so that the electrode will give best operation on desired polarities.
6. Give stability to the arc through ionization of coating materials and provide sufficient coating to form a cup or sleeve around the end of the electrode concentrating and directing the arc.
7. Produce a slag that is easy to remove.
8. Act as a flux to purify the weld metal.
9. Provide a medium through which alloys can be added to the deposited metal.
10. Bind coating materials and core wire together.
11. Give a low spatter loss or high efficiency.

To satisfy the first two requirements, coating materials must furnish sufficient organic substances which upon decomposition will produce the reducing atmosphere and material to give the fast-setting slag and weld metal. These organic materials are usually cellulosic fiber, gums, starches and/or sugars and constitute approximately 30% of the coating. The protective atmosphere formed by this type of an electrode has the approximate composition 1.0% CO_2, 55% CO, 42% H_2 and 1.5% water vapor.

Conditions requiring the use of organic materials are dictated by the nature of the other coating materials. The nature and type of coating desired determine whether or not organic materials will be used. For example, if bulk is required cellulosic materials are used; if otherwise, starches and gums may predominate. In addition to furnishing bulk to reduce the density of the coating, cellulosic fibers give strength to the coating by interlocking; starches and gums furnish a certain amount of adhesiveness to help bind the coating materials together.

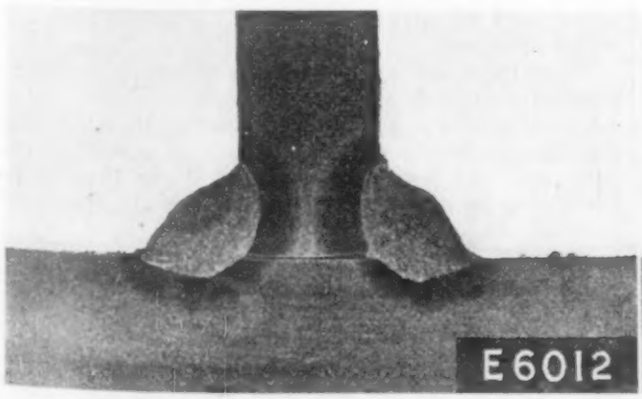

Fig. 3—Fillet Profile of E6012 Made with $^5/_{32}$-In. Electrode, 170 Amp., 22 V., Straight Polarity. 2 ×

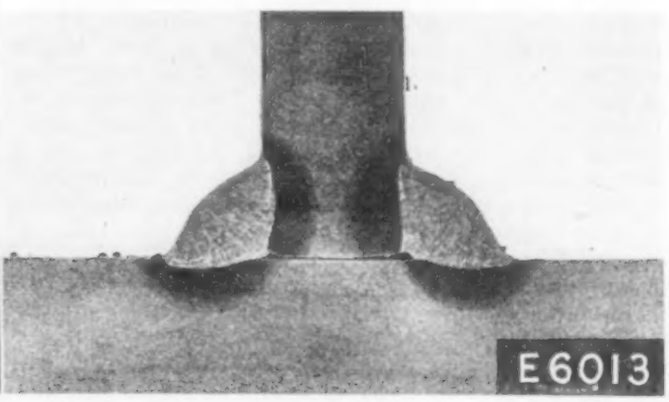

Fig. 4—Fillet Profile of E6013 Made with $^5/_{32}$-In. Electrode, 170 Amp., 22 V., A. C. 2 ×

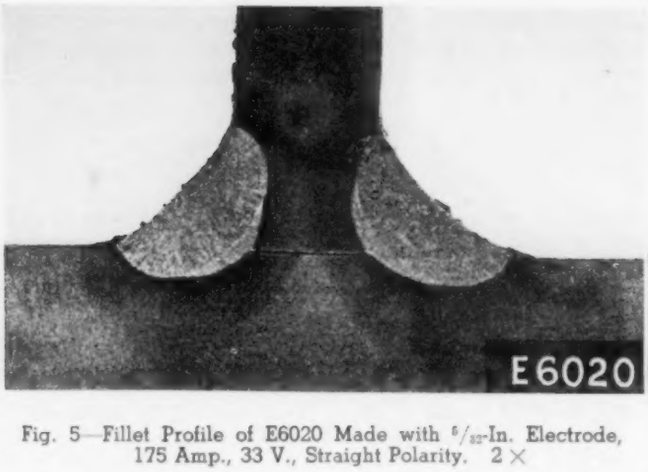

Fig. 5—Fillet Profile of E6020 Made with $^{5}/_{32}$-In. Electrode, 175 Amp., 33 V., Straight Polarity. 2 ×

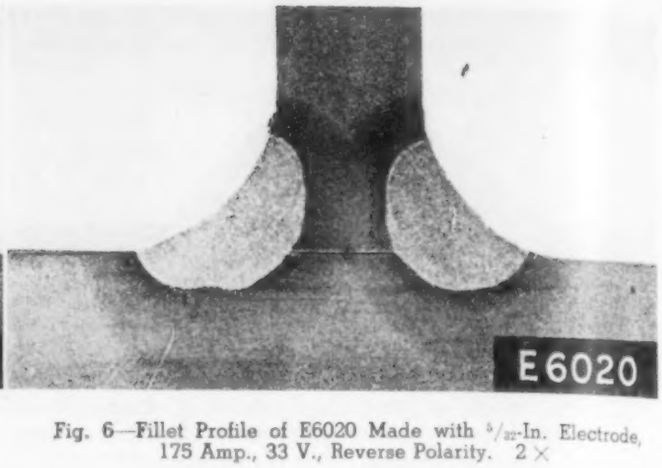

Fig. 6—Fillet Profile of E6020 Made with $^{5}/_{32}$-In. Electrode, 175 Amp., 33 V., Reverse Polarity. 2 ×

Coatings for out-of-position welding must produce slags that have a rapid change of fluidity with temperature. The slag must be sufficiently fluid to give proper fluxing action while the arc is concentrated in the molten pool but will solidify sufficiently fast to prevent the metal from running as the arc progresses forward. The freezing rate must not be so rapid that it will cause slag entrapment in the metal or prevent the dissolved gases from rising to the surface of the weld deposit. Fluidity in both slag and weld metal can be controlled through the slagging constituents incorporated in the coating. Magnesium, calcium and aluminum compounds are generally employed to aid in decreasing the viscosity range. Titanium dioxide and silicon dioxide are generally employed to increase the viscosity range. Thus by balancing the coating with a variation of these ingredients the regulation of fluidity to bring about the proper freezing rate of weld deposit can be effected. Magnesium is in the coating as silicate such as talc or asbestos, calcium as the carbonate and aluminum as silicate such as feldspars and/or clays.

The penetration is controlled by the voltage across the arc, the polarity of the electrode, the amount and kind of gases in the arc stream. The voltage is largely determined by the thickness of the coating and the ionization of the elements in the arc stream. High ionic emissivity increases conductivity and decreases arc voltage, hence materials such as titanium compounds increase conductivity and melting rate and reduce the arc voltage and penetrating properties. Decreasing the coating thickness decreases the length of the shielding sleeve formed at the end of the electrode and causes the arc stream to be spread over a greater area, thus decreasing its penetrating properties. To maintain the same arc characteristics the gap may be reduced which results in a lower arc voltage. This reduction in arc voltage, however, is a result of a change in arc length and may actually result in an increase in penetrating properties of the electrode rather than decreasing it. Direct-current welding in general gives greater penetration than a.-c. with the reverse polarity exceeding that of the straight polarity. Thus where shallow penetration is desirable, a.-c. electrodes are becoming more popular and for deep penetration, d.-c. reverse polarity electrodes are preferable.

The regulation of electrical characteristics of the arc so that the electrode will give the best operation on desired polarities is accomplished entirely with amount and selection of coating materials. In general, good arc-stabilizing materials such as titanium, potassium and sodium compounds predominate in a.-c. and d.-c. straight polarity electrodes and such compounds as those of calcium, magnesium, aluminum and cellulosic materials aid in producing reverse polarity electrodes.

The fundamental mild steel electrodes usually contain carbon and manganese as the principal alloying elements. Since both of these elements are burned out in the arc, the coating material must contain both to make good the loss of these elements. Ferromanganese is generally used for furnishing the manganese and some of the carbon. Organic materials furnish the remaining carbon.

Since these electrodes are used in multiple pass joints the slag must remove easily to facilitate the welding procedure. In general this can be accomplished by balancing the acid- and base-forming constituents in the coatings to give a slag having a low coefficient of expansion. A commercial E6010 electrode coating composition which produces a slag that is easily removed is given in Table 4.

The fluxing ability of the slag is its property to react with and dissolve oxides of the weld deposit and carry them to the surface. The degree of fluxing depends upon the fluidity and composition of the slag. In general, welding slags are on the acid side and the regulation of its fluidity is accomplished by varying the acid- and base-forming constituents of the coating.

Fast deposition is accomplished by increasing the amperage which necessitates a coating that will withstand high temperature without breaking down in advance of the arc. Fortunately this property of heat resistance is supplied by mineral silicates used for fulfilling requirements of other properties already discussed.

Liquid sodium and potassium silicates are almost exclusively used as the binding agent in heavy-coated electrodes. They constitute about 20% of the dry weight of the coating. Gums and starches are sometimes used to augment the binding properties of the liquid silicates.

While there are several theories offered to explain the cause of spatter no single one is as yet accepted, yet the electrode coater can hold this spatter to a minimum through the selection and balancing of coating ingredients and core wire composition. When the essential conditions for a good electrode are met the spatter will generally be low.

Many of the improvements in modern heavy-coated electrodes are due to the efforts of the suppliers in furnishing new, more uniform and purer materials.

The E6010 type is one of the oldest and most widely employed electrodes today. It is suitable only for d.-c. welding and with the increased use of a.-c. equipment this limitation is reducing its popularity.

The E6011 type of electrode, although holding a posi-

Table 4—Coating, Slag and Weld Metal Compositions of Representative Commercial Electrodes from the Three Fundamental Groups

Constituents	A.W.S.-A.S.T.M. Classification Nos.									
	E6010		E6011		E6012		E6013		E6020	
	Coating, %	Slag, %	Coating, %	Slag, %	Coating, %	Slag, %	Coating, %	Slag, %	Coating, %	Slag, %
SiO_2	32.9	37.8	22.9	....	19.6	17.6	25.9	....	31.4	43.5
$TiO_2 + ZrO_2$	13.9	17.6	25.3	....	42.2	46.3	30.6	....	....	....
Al_2O_3	1.7	3.6	0.5	....	2.3	5.1	5.9	....	1.8	5.9
Fe_3O_4	....	....	....	....	....	....	....	....	31.8	....
Fe_2O_3	....	....	....	....	....	0.8	....	....	....	1.8
FeO	....	....	....	....	....	6.3	....	....	....	14.5
MnO	....	15.6	....	....	....	14.7	....	....	....	23.8
CaO	0.8	1.2	1.8	....	3.5	0.2	1.6	....	2.3	3.3
MgO	4.6	6.2	8.3	....	4.4	4.7	2.6	....	0.4	....
Na_2O	8.6	....	3.8	....	3.1	2.9	1.1	....	2.6	3.7
K_2O	....	....	4.4	....	1.5	1.7	6.7	....	1.3	2.2
CO_2	0.3	....	2.3	....	3.1	....	1.7	....	2.6	....
Organics*	28.9	....	23.9	....	10.2	....	17.7	....	9.6	....
Fe	1.8	....	1.9	....	2.8	....	2.1	....	2.8	....
Mn	6.5	....	5.2	....	7.6	....	4.8	....	14.6	....

Element	Weld Metal Analysis, %				
C	0.09	0.10	0.08	0.07	0.10
Mn	0.42	0.46	0.35	0.40	0.37
Si	0.25	0.18	0.13	0.13	0.16
P	0.03	0.03	0.03	0.03	0.03
S	0.03	0.03	0.03	0.03	0.02

* Includes H_2O.

tion in the electrode classification chart for several years, has only been developed in quality equal to the E6010 in recent years. Originally it was intended for a.-c. operation primarily but more recent developments have resulted in an electrode which operates equally well on d.-c. reverse or straight polarity. The over-all quality of this modern electrode is also superior to that of the E6010. This improvement gives the advantage of having one type of electrode where both types of welding machines are in use. With this versatility of operating characteristics it is destined to become the most popular electrode for all-around quality welding.

The difference in current-operating characteristics of these two electrodes is accomplished by the introduction of arc-stabilizing ingredients such as the new commercially developed potassium and titanium compounds without any appreciable change in the gas-shielding atmosphere and slag action. This change results in a better energy distribution between anode and cathode.

The coating analysis of a commercial E6010 and E-6011, the slag analysis of the E6010 and the weld deposit analysis of both are given in Table 4.

Group II—E6012 and E6013

While the E6010 and E6011 are high-quality electrodes for use in all positions, their harsh digging arc made them unsuitable for many applications. Another type all-position electrode was needed that possessed a more shallow penetration and the property to bridge or close wide openings like bare or sul-coated wire. Unlike the bare or sul-coated wire, good weld metal physical properties, arc stability and ease of handling were desired. The development of an electrode of this type followed very closely that of the cellulosic and constitutes the E6012, whereas the E6013 is a modern development.

The characteristic convex fillet profile and shallow penetration of this group are shown in Figs. 4 and 5 and Table 3.

The quality of the E6012 as shown by X-ray and ductility is not so good as those in Group I. It was necessary to sacrifice to some extent the metal quality in order to get the ease of handling, better-appearing bead and increased rate of deposition. This of necessity restricts its use in some applications where high stresses are involved and great fatigue strength is required.

More recent developments in electrodes of this group have produced the E6013, which was originally intended for a.-c. welding primarily but with the more recent improvements operates equally well on a.-c. and d.-c. currents. The quality of the weld deposit of this electrode approaches, with the lone exception of ductility, that of the E6010 and E6011. It has the advantage over E6012 of better arc stability, permitting its operation at a lower open circuit voltage, easier slag removal, better-appearing weld bead with operating characteristics permitting a long arc to be maintained with shallow penetration, an essential combination for light gage welding.

In order to produce a weld capable of bridging wide openings, the slag must be more viscous with a higher freezing point than the E6010 and E6011 types. These properties are obtained by increasing the oxides and silicates and reducing the organics, resulting in a higher melting point, more dense slag which results in a better slag coverage and a better-appearing bead. The raising of slag melting point and reduction of the organics result in a less gas-shielding atmosphere thus giving a weld deposit with slightly more impurities.

As above mentioned, the quality of the E6013 is superior to that of the E6012, brought about largely by the introduction of additional arc-stabilizing ingredients such as potassium compounds and organic material to increase gas-shielding properties. A better balance of energy distribution between anode and cathode is obtained. The coating analysis of a commercial E6012 and E6013, the slag analysis of the E6012 and the weld metal analysis of both are given in Table 4.

Some specific applications of this group are found in welding low-pressure storage vessels, safety guards of light-gage steel, sheet-metal fabrications such as automobile cab bodies, farm machinery, steel frame constructions and general maintenance. The neat appearance combined with fast welding speed lead to low cost fabrication with adequate weld quality. They are generally recommended for structural welding of all kinds where sufficient metal can be deposited in a single pass

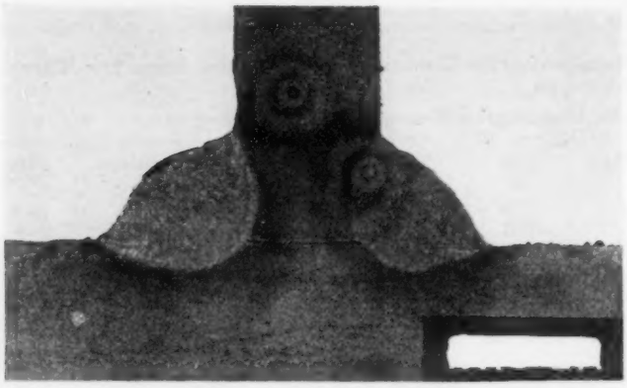

Fig. 7—Fillet Profile Made with $^{5}/_{32}$-In. New Ferritic H. T. Electrode, 195 Amp., 25 V., Reverse Polarity. 2 ×

to give necessary strength in the joint. It is also used for the cover bead over multiple pass work of the E6010 electrode where good appearance is required.

Group III—E6020 and E6030

In the E6020 and E6030 classification there is no corresponding improvement comparable to the all-position groups. A new application, however, has been introduced with this group of the so-called "hot rods" in which a deep-fillet weld in the flat or horizontal positions is deposited by using a high current, holding a very short arc and traveling at a high speed. Using this technique a significant increase in penetration is obtained beyond the root of the weld which measurably increases the strength of the weld, and because of the deeper penetration obtained much of the weld metal is derived from the base metal of the parts being joined, thus effecting a saving in electrode consumption.

Essentially the E6020 was designed for horizontal fillet and flat position welding while the E6030 type is used in the flat position only. Figures 5 and 6 show the characteristic concave fillet welds of this group when using recommended amperages. Both electrodes operate satisfactorily on d.-c. and a.-c. currents, the former originally intended for a.-c. and d.-c. straight polarity, whereas the latter was intended for a.-c. and d.-c. reverse polarity. Fundamentally the E6020 will weld in the flat positions equally as well as the E6030 with equal weld metal qualities; thus it is very probable that the E6020 will eventually replace the E6030 type, removing it from a separate classification.

The coating composition of these classes is essentially all mineral of the iron oxide, oxidizing slag shielding type. The coating thickness is much greater than either of the all-position groups resulting in the formation of a heavy slag which performs a metallurgical refining operation by dissolving refractory oxides, cleaning and deoxidizing the metal and shielding the molten metal from the oxygen and nitrogen of the atmosphere. The slag is more fluid with a lower viscosity and surface tension which restricts their use to horizontal and flat position welding on fairly close-fitting joints. The all-mineral coating and its greater thickness enable this electrode to be used with very high welding currents thus resulting in a very fast deposition and deep penetration with a resulting weld deposit of exceptionally high quality. Perhaps the refining action of the slag and the slower cooling of the deposit, yielding an exceptionally fine-grain metal free from impurities, are contributing factors to its high weld quality rather than the chemistry of the weld deposit. The coating, slag and weld metal analysis of a commercial E6020 type are given in Table 4.

New High-Tensile Ferritic Electrodes

During the last few years American welding was called upon to fabricate heavy steel structures from alloy steel of high strength and high hardenability. Since it was not always practical to heat treat the weldment, austenitic welding electrodes were used because of their excellent weld metal physical properties and their ability to make sound ductile welds with and without preheating and/or postheating. The tendency for base metal cracking to occur even when preheat and postheat was used in the welding process made the mild steel class of electrodes unsuitable for this type of fabrication.

Some of the disadvantages of the austenitic electrodes for this type of welding are:

1. Cost.
2. Availability of alloys.
3. Difference in properties of base and weld metal—such as expansion and contraction.
4. Difficulty of repairing defective welds—austenitic must be machined, ground or chipped while mild steel or ferritic weld metal may be flame cut or gouged out.
5. Relatively slow speed of welding of the austenitic electrode.

These disadvantages clearly indicate that a ferritic electrode was needed to weld high hardenable steels without causing base or weld metal cracking.

Herres[3] lists a number of factors which he considers responsible for underbead cracking as follows:

1. Chemical composition of the steel.
2. Processing of the steel prior to welding.
3. Arc heat input.
4. Weld cooling rate.
5. Volume change during cooling.
6. Ability of hardened area to relieve stresses.
7. Restraint of weldment.
8. Precipitation of dissolved hydrogen in the fusion zone.

The electrode manufacturers should appreciate the effort of Watertown Arsenal to evaluate properly the

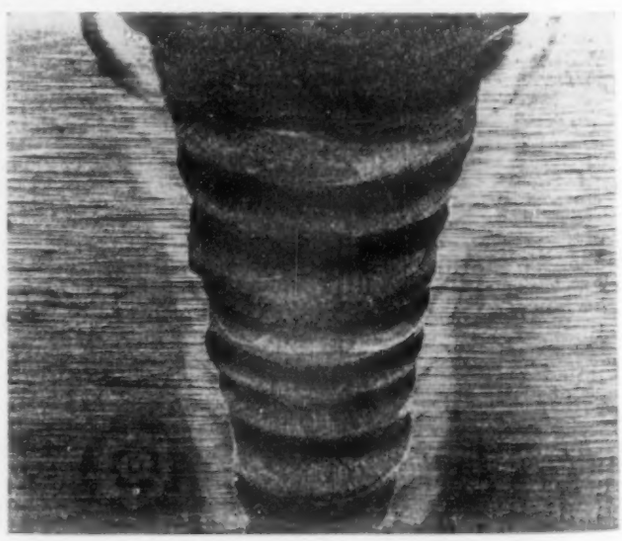

Fig. 8—Photomacrograph of Transverse Tensile Test Weld in $1^{1}/_{2}$-In. H. T. Steel Plate Made with $^{5}/_{16}$-In. Ferritic Electrode. 2 × (Table 5)

welding difficulties heretofore largely placed upon the electrode for lack of a better understanding of welding metallurgy. In this list of factors there are actually only two that the electrode manufacturer can control, namely, the hydrogen precipitation and, to a small extent, the arc heat input.

With all these other factors properly controlled, an electrode is still required which can be used with the proper arc heat input and a coating composition which upon decomposition will not liberate hydrogen that will precipitate in the weldment. This requirement is met with an all-mineral-coated electrode with a high carbon dioxide-hydrogen ratio such as used on austenitic electrodes. Although the same coating applied to a ferritic core wire may fulfill these two requirements, it still lacks those properties necessary for satisfactory performance, such as given by the fundamental type of electrodes. It is desirable that this type of electrode produce a weld metal quality comparable to that of the EXX20 series, and perform as satisfactorily in all positions as the EXX10 and EXX11 series.

In view of the evidence now existing that hydrogen compounds present in the arc are a contributing factor to this base metal cracking, coatings without organic materials are necessary. This limits the coating ingredients to inorganic materials and the most successful compounds used to date are calcium carbonate, calcium fluoride, magnesium aluminum silicates and ferro alloys with the usual binding agents sodium and potassium silicates.

Satisfactory coating compositions have been developed for horizontal and flat position welding, but more difficulties are encountered in securing a balance of ingredients that will give good sound weld metal in the vertical and overhead positions with the uses of welding currents possible in these positions. Therefore it is to be expected that a satisfactory electrode for this requirement would be first obtained for flat and hori-

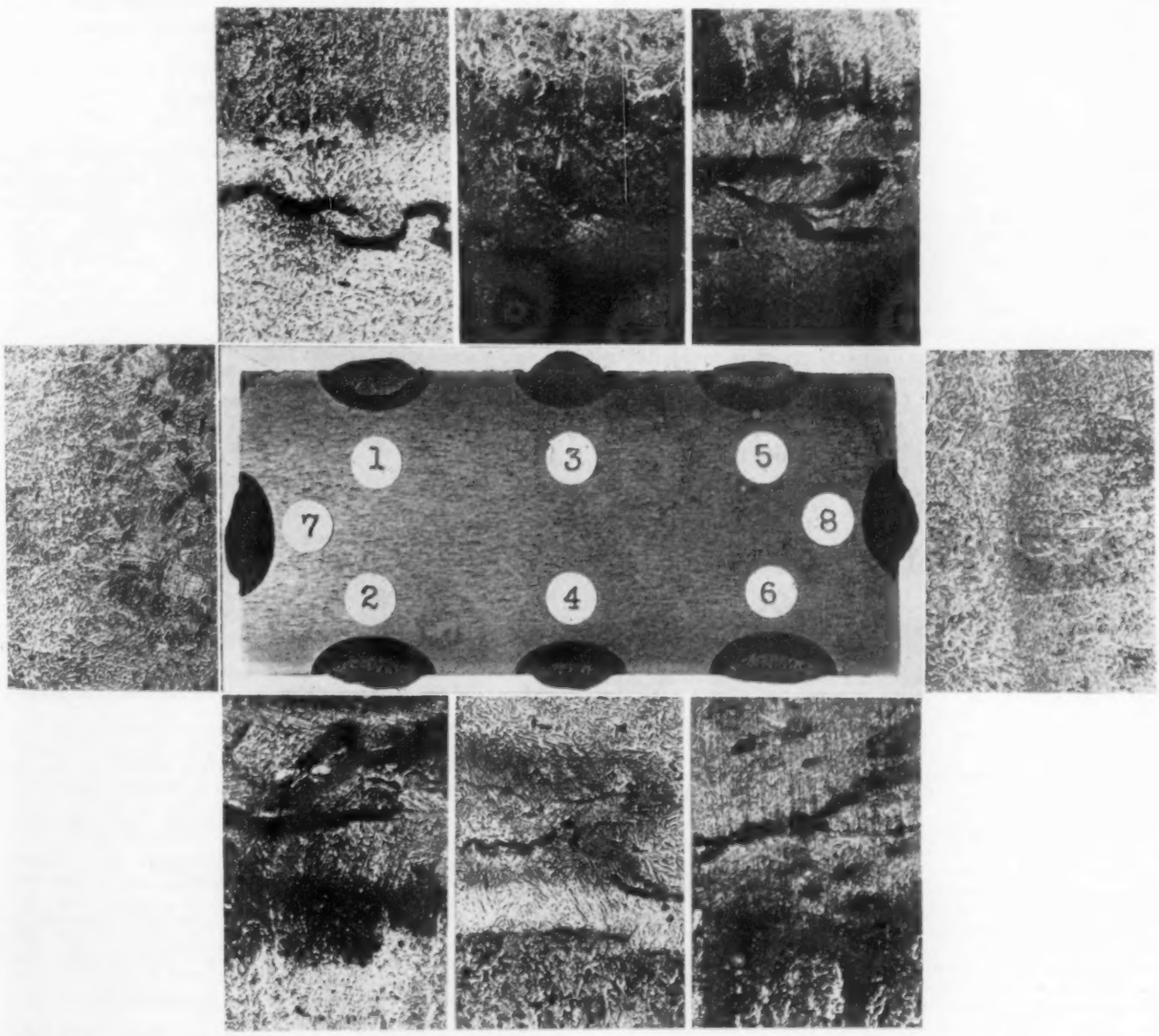

Fig. 9—Photomicrographs Showing Typical Base Metal Cracking of Six Commercial Mild Steel Electrodes and the Absence of Cracks of Two Ferritic Electrodes. 50 ×

1. E6010—Rev. Pol.
2. E6011—A. C.
3. E6012—Str. Pol.
4. E6013—A. C.
5. E6020—Str. Pol.
6. E6020—Rev. Pol.
7. Ferritic (High Tensile)
8. Ferritic (Low Tensile) Rev. Pol.

Deposits Made on 1 1/2-In. H. T. Steel Plate with 3/16-In. Electrodes, 200 Amp., at Approximately 8 In. per Minute

Table 5—Physical Properties of a Commercial High-Tensile Ferritic Electrode

	As-Welded			Stress Relieved	
Transverse tensile, psi.*	106,800			112,500†	
% Elongation in 2 in.	15.0			20.5	
% Reduction in area	38.0			52.0	
All-weld metal‡					
Ultimate tensile strength, psi.	105,700			94,200	
Yield point, psi.	86,700			81,700	
% Elongation in 2 in.	20.5			24.5	
% Reduction in area	26.6			66.8	
Impact strength (Charpy)					
Temperature, ° F.	70	30	0	−30	−50
Load, ft.-lb.	40	38	37	34	33
Rockwell C hardness values					
Weld metal	24–28				
Fusion zone	26–30				
Base metal	28–29				

* Standard Navy "torture" test plate procedure (46E4 (INT) July 1, 1944) using $1^1/_2$-in. plate was followed in making these transverse tensile test bars.

† Water quenched from 1650° F. and drawn at 1150° F.

‡ A.W.S.-A.S.T.M. Specification A233–43T procedure followed in making these all-weld metal tensile test bars.

zontal welding. Such an electrode is now available for satisfying these requirements on the high-strength air-hardenable steels.

Similar advancement with the lower strength all-position type electrode is lagging somewhat, but progress is being made due to the urgent need and impetus given this type of electrode in the shipbuilding program where low-alloy high-tensile steels are used.

Physical properties of the E90 and E100 series are given in Table 5. A photomacrograph of weld deposit in a transverse tensile specimen is shown in Fig. 8 and photomacrographs of weld-bead deposits on High Tensile Steel plate of each of the six fundamental groups together with the new ferritic type are shown in Fig. 9.

Underbead weld cracking of the fundamental groups and the absence of cracks in this new ferritic type are illustrated in the photomicrograph inserts.

The results obtained from further investigations indicate, however, that the tendency for underbead weld cracking with plain high-carbon steel (0.35 to 0.85% C) was not as pronounced as steels of high hardenability obtained by alloying a medium-carbon steel (0.25 to 0.35% C) with other elements such as chromium, nickel, molybdenum, etc.

Results not published in this report obtained on weld test specimens made in a completely restrained single Vee butt joint of $^3/_4$-in.-thick 0.60% carbon steel using $^3/_{16}$-in. electrodes from each of the fundamental groups showed no cracking when cross sectioned and "magnafluxed," or etched and examined under the microscope.

The specimens were welded using the recommended amperages for each electrode and an interpass temperature between 220–240° F.

Transverse tensile bars were cut from these weldments and the ultimate tensile strength and per cent elongation results showed no indication of cracking.

Acknowledgments

The authors extend their appreciation to Mr. William Hyink who prepared the samples and photographs and assisted in the slag analysis and to Dr. Richard Frank who made the coating and slag analysis.

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(*Continued on page 568*)

Basic Definitions of Welding Technology*

By C. H. Jennings†

WELDING is defined as a localized consolidation of metals and covers that group of processes employed to produce fusion between two or more pieces of metal. The joining of metals by fusing them together makes it unnecessary to employ bolts, screws or rivets. It also eliminates, except in the case of spot welding, the need of flanges, angles and gusset plates which frequently add weight and complicate the design (Fig. 1). Even though flanges, angles, etc., are required in spot welding, many advantages are obtained, such as: fewer parts, no punching or drilling of holes and no strength reduction resulting from the bolt or rivet holes.

At the present time welding is accomplished in five principal ways: (1) forge welding, (2) gas welding, (3) thermit welding, (4) electric arc welding and (5) resistance welding. Although this course is primarily concerned with only one of these processes (resistance welding) it will be of advantage to obtain a general perspective of the entire field. That group of processes known as brazing processes and the various patented processes based on minor modifications and combinations of these five principal processes will not be considered.

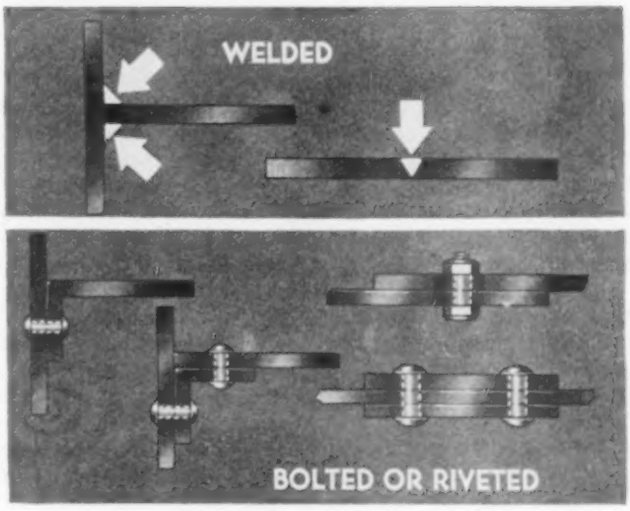


Fig. 1

Forge Welding

Forge welding, probably the oldest method of welding, takes its name from the blacksmith's forge. This process is generally limited to irons and low-carbon steels and plain simple joints. Welding is accomplished by heating the edges to be welded to the plastic stage (below the melting point) by some suitable means such as a forge, furnace, gas flame, etc., and then fusing the plastic surfaces together by means of pressure obtained from a hand, power hammer or some other source. No filler metal is required with this process.

Most forge welds are made by lapping the surfaces to be welded and forging them to a uniform thickness so that the surfaces of the two parts are in the same plane (Fig. 2 (*a*)). Some processes, however, employ a square butt joint of the type shown in Fig. 2 (*b*).

Although forge welding is not as extensively used as the other welding processes it is still frequently used in railway repair shops, country blacksmith shops, and in the construction of some pressure vessels and pipe.

The longitudinal seams of pressure vessels are welded by beveling the edges, progressively applying heat to the edges by means of large gas flames, and progressively forging the heated edges together by using a power hammer. Pipe welding is generally done by heating flat strip in a furnace and then drawing the strip through a tapered ring known as a bell. The bell forms the strip into a circle, and because its inner diameter is slightly smaller than the periphery of the strip when it is formed into a ring, considerable pressure is applied to the butting edges which completes the weld (Fig. 2 (*c*)).

Gas Welding

The process of gas welding accomplishes fusion of the metals solely by the heat of combustion of suitable gases. No pressure is used to complete the weld as in the case of forge welding.

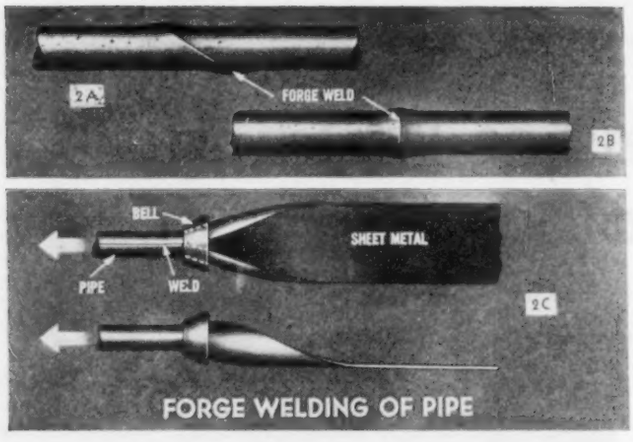
A large number of gases may be used for gas welding such as oxygen and acetylene, oxygen and hydrogen, oxygen and propane, etc. The oxygen-acetylene combination produces a flame of the highest temperature and is almost universally used except for the welding of aluminum in which case oxygen and hydrogen are commonly preferred.

In this process, the heating or welding flame produced by the combustion of mixed gases supplies heat only and does not add filler metal to the joint. The need for filler metal depends upon the joint design and when required is obtained by melting the plate edges (Fig. 3 (*a*)), melting a joint insert (Fig. 3 (*b*)) or progressively feeding a rod or bar into the joint as welding progresses (Fig. 3(*c*)). The equipment necessary for gas welding includes among other things, tanks to store gases, regulators to control the gas flow, hoses, torch and tips of various sizes. In cases where large quantities of acetylene are used acetylene generators are often employed.

Gas welding is a more flexible process than forge welding and is used on a wide variety of materials, structures and joints. One of the outstanding features of gas

* One of a series of articles furnished by the Westinghouse Electric Corp. covering a course in resistance welding control.

† Welding Engineer, Westinghouse Research Laboratory, East Pittsburgh, Pa.



Figs. 2 (*a*), 2 (*b*) and 2 (*c*)

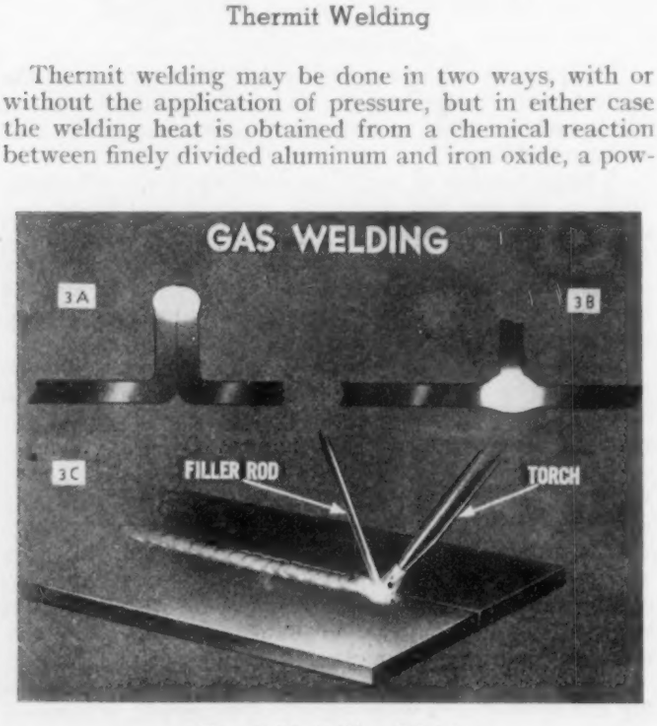
welding is that by properly controlling the gas mixtures the welding flame can be adjusted from reducing to oxidizing conditions. This property of being able to control the type of welding flame makes gas welding suitable for use on nearly all types of materials that are weldable such as low-carbon steels, alloy steels, cast iron, copper, brass, bronze, nickel and nickel alloys, aluminum, etc.

Although gas welding can be used to weld nearly every type of material, its application is frequently limited because of economic reasons. Thin materials are readily gas welded, but as the thicknesses increase the welding speed decreases to a point where other methods of welding are generally preferred. It is not possible to place any limit on the maximum thickness of material that should be gas welded because it depends on the type of structure and the materials used. Materials under $^1/_{16}$ in. thick are particularly adapted to gas welding while materials about $^1/_4$ in. thick, with the exception of the nonferrous groups, are preferably welded by some other process.

Gas welding is applicable to the welding of all types of joints in all positions. It can also be done manually or automatically.

Thermit Welding

Thermit welding may be done in two ways, with or without the application of pressure, but in either case the welding heat is obtained from a chemical reaction between finely divided aluminum and iron oxide, a powdery mixture known as thermit. Nonpressure thermit welding is the most common type and has the widest application.



Figs. 3 (*a*), 3 (*b*) and 3 (*c*)

Nonpressure thermit welding consists essentially of casting the filler metal between the ends of the parts to be welded. The process is carried out in the following way: the parts to be welded are separated a suitable amount and the area to be filled with weld metal is filled with wax so that the wax will have the desired shape of the finished weld. A fire clay mold is next built around the wax form and metal ends and properly gated and vented (Fig. 4). Following this the wax is melted out and the ends of the parts preheated to a dull red. (The weight of the wax used is a measure of the thermit required to make the weld.) The thermit is placed in a crucible above the mold and ignited when the parts are properly preheated. This ignition starts the thermit reaction which turns the powdered thermit into a superheated molten mass consisting of iron at a temperature of 5400° F. covered with an aluminum oxide slag. The molten iron is tapped from the bottom of the crucible into the mold and fuses to the parts to form a homogeneous mass of metal. The mold is subsequently removed, and the gates and risers cut off.

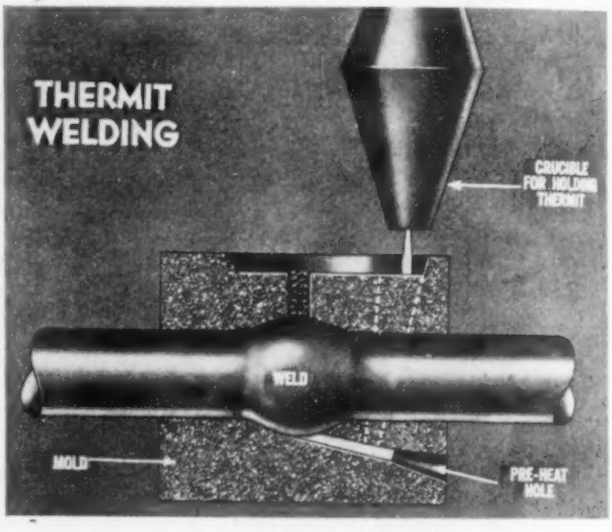


Fig. 4

The analysis of the thermit weld can be controlled by the nature of the materials used to make the powdered thermit. Cast iron, mild steel and low-alloy steel thermit welds are commonly made.

This process is generally applied to large heavy sections where the ratio of the joint length to the thickness is not too large. It is particularly adapted to the repair welding of large parts such as broken shafts, steel mill rolls, rolling mill frames, etc., although it is also used to fabricate new structures such as stern parts for ships.

Pressure thermit welding is essentially a forge welding process wherein the superheated iron and aluminum oxide slag resulting from the thermit reaction are used as the source of heat. Its applications are limited but it has found extensive use in the welding of pipe and street car rails. The majority of all-welded street car rails are probably welded by this process.

The method of making pressure thermit welds is essentially as follows: the parts to be welded have their ends cut square and are mounted in a clamping mechanism which makes it possible to apply high pressure to the joint. A cast-iron mold is mounted around the member at the joint as shown in Fig. 5. A thermit charge of the proper amount is ignited and after the reaction is com-

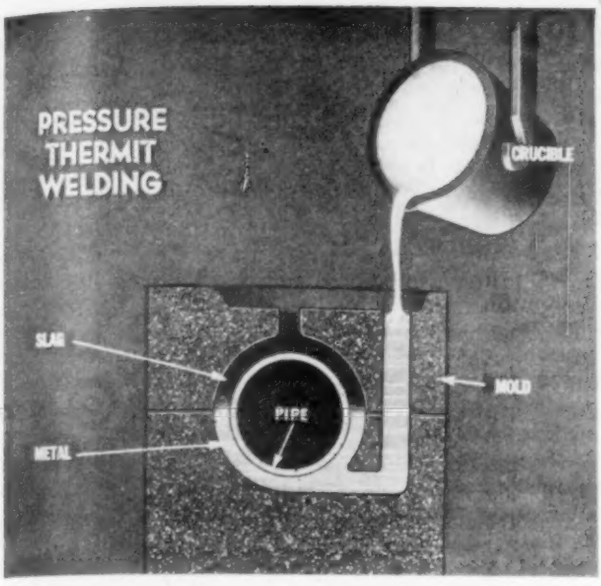


Fig. 5

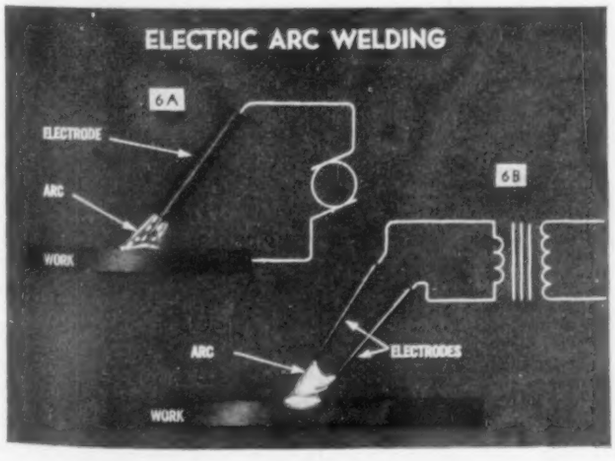
pleted the molten slag and metal are poured into the mold, slag first. The charge is proportioned so that the molten metal only comes to about the center line of the parts being welded. The hot metal and slag heat the contact ends of the materials to be welded to the plastic state following which pressure is applied which completes the weld.

After the weld has cooled to the desired point the cast-iron mold is removed, the half rings of slag and metal broken away thereby leaving the welded joint free of any extraneous material. By pouring the slag into the mold first, the surfaces of both the mold and materials being welded are lightly coated with slag so that the molten metal will not stick to them.

Electric Arc Welding

In this process the welding heat is obtained from the energy of the electric arc and, as in gas welding, no pressure is used. In general, the arc is struck between a suitable electrode and the work (Fig. 6 (*a*)), although in some variations of this process the arc is struck between two electrodes and the arc flame impinged upon the work (Fig. 6 (*b*)).

In metal arc welding the electrode is made of a suitable metal which melts under the heat of the arc and deposits



Figs. 6 (*a*) and 6 (*b*)

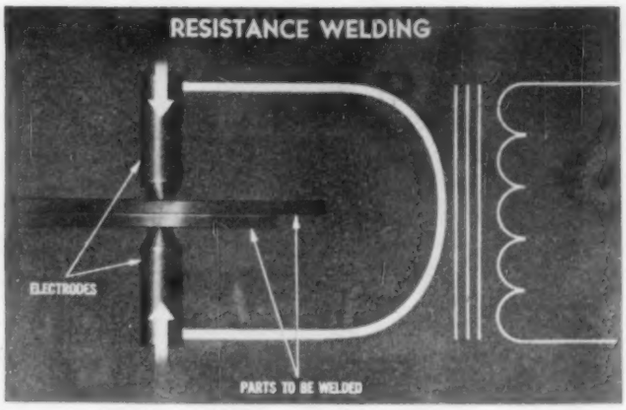


Fig. 7

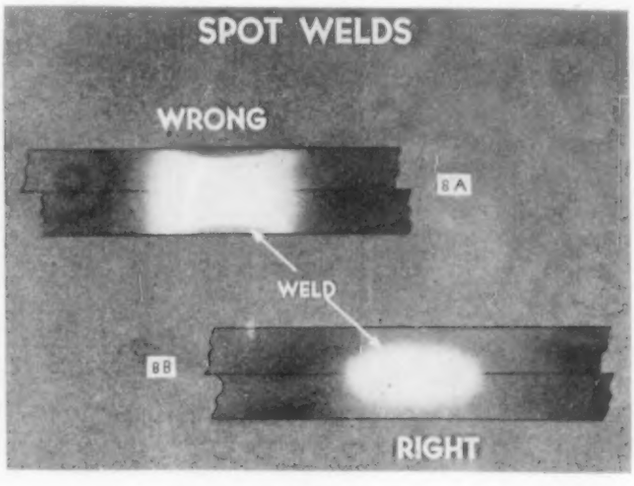
filler metal onto the molten work. In carbon arc welding the arc is drawn between a carbon or graphite electrode and the work. The addition of filler metal in this case is accomplished by melting down the edges of the work or by inserting a filler rod into the arc. When the double electrode system is used (Fig. 6 (*b*)) filler metal is added in a manner similar to that described for carbon arc welding.

Metal arc welding is a most generally used process because it has a very universal application. For the production of high quality welds electrodes having a flux coating are used. This coating is designed to improve the quality of the weld, add alloy elements and control the weld chemistry, control the electrode melting rate and improve the arc stability. Many varieties of electrodes are available making it possible to weld low- and medium-carbon steels, alloy steels, cast-iron aluminum, bronze, brass, nickel, monel, inconel, etc. Welding can be done in all positions on all types of joints.

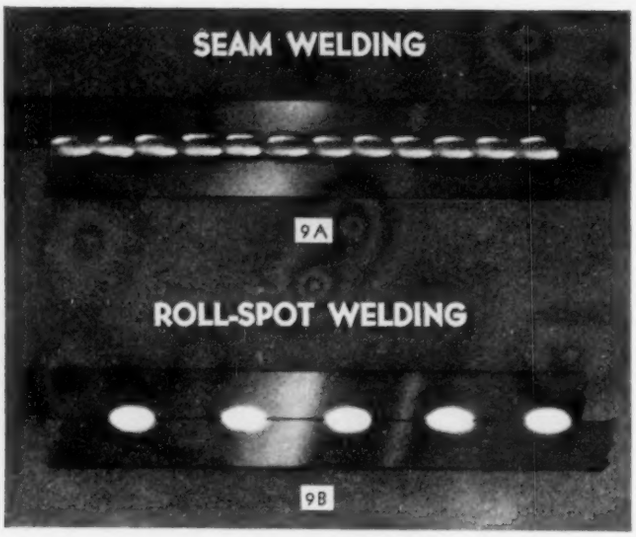
Arc welding is particularly adapted to materials $^1/_8$ in. thick and above, but it has been used on materials less than $^1/_{16}$ in. in thickness.

Both a-c and d-c power sources are used for metal arc welding, and each have their advantages. Alternating current is often preferred for complicated work and heavy current welding because of its relative freedom from arc blow and the simplicity and efficiency of the equipment. The primary advantage of dc equipment is that it can be used in the welding of nonferrous metals and carbon arc welding, and either dc or three-phase power can be employed.

Carbon arc welding is not used extensively, although



Figs. 8 (*a*) and 8 (*b*)



Figs. 9 (*a*) and 9 (*b*)

it has found a definite field in automatic welding and in the welding of nonferrous metals having high heat conductivity. The fact that the carbon electrode does not add filler metal makes it possible to control the rate of advance and puddle the weld sufficiently to insure melting of the base metal and proper fusion.

Electric arc welding of all types can be done both manually and automatically and the welding speeds obtainable make it preferable to gas, forge and thermit welding, in most cases. It is applicable to long and short seams and a wide range of material thicknesses. Consequently it has developed into the most generally used welding process.

Resistance Welding

Resistance welding covers a group of processes wherein the welding heat required to make the weld is produced from the resistance offered by the parts and contact surfaces to the passage of a heavy electric current. Pressure is used in combination with the heating to complete the weld. Types of resistance welding are spot welding, projection welding, seam welding, resistance butt welding and flash welding. For the purpose of discussion, only the spot welding process will be described.

In spot welding, the pieces to be welded (two or more) are clamped between two copper or copper alloy electrodes (Fig. 7) mounted in a suitable machine capable of applying pressure between the electrodes. These electrodes are used to conduct the welding current and to supply pressure to the parts. Usually they are water cooled to help prevent sticking, burning and deformation under heat. The weld is made by passing a heavy current through the electrodes and work pieces. This heavy current is obtained by practically short circuiting the secondary of an extremely high current welding transformer.

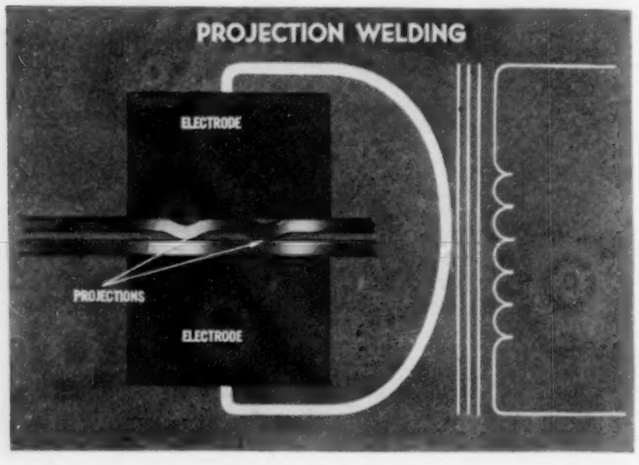


Fig. 10

The resistance of the metal pieces and their contact surfaces to the heavy current passing through them causes intense heating. This heating, in combination with the applied pressure of the electrodes, produces fusion between the parts, resulting in a circular weld known as a spot weld. The size and diameter of the spot weld will depend upon many factors such as, type and thickness of parts being welded, diameter and shape of electrodes, amount of pressure, amount of current and welding time. These factors will also affect the size of the fused nugget of the weld. In some cases fusion of the metals may extend to the outer surfaces (Fig. 8 (*a*)), while in other cases it may be confined to a narrow volume as shown in Fig. 8 (*b*). In general, a controlled nugget of the type shown in Fig. 8 (*b*) is preferred, and on certain materials such as stainless steel and Alclad aluminum it is essential if proper corrosion resistance is to be preserved.

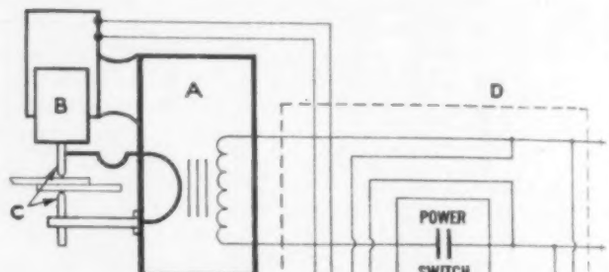


Fig. 11

Seam welding is a process similar to spot welding and varies in that rollers are used for electrodes. By properly timing the periods of current flow as the parts are passed between the roller electrodes a series of spot welds are made. If the spots overlap a continuous weld is made (Fig. 9 (*a*)). If the spots do not overlap (a space is left between each weld) (Fig. 9 (*b*)) the process is known as stich or roll spot welding.

Projection welding is another variation of spot welding and consists of placing projections on one of the pieces to be welded (Fig. 10), after which current is passed through the work pieces. Large electrodes are generally used in this process and the projection locates the points at which the welds are made. Projection welding is particularly adapted to the production of more than one weld at a time (Fig. 10), and to the welding of two pieces varying greatly in thickness.

Resistance welding is a high-speed process and is particularly adapted to production work, especially to the quantity production of small parts. It is applicable for use on a great variety of materials both ferrous and nonferrous, and although it is most commonly applied on parts $^1/_4$ in. or less in thickness recent developments

have extended the process to the welding of materials $\frac{1}{2}$ in. thick and above.

The increased knowledge of the metallurgy of resistance welding combined with modern resistance welding machines and control has vastly increased the application of this process. The principal elements of a modern resistance spot welder are shown in Fig. 11.

A is a heavy frame supporting an extremely high current transformer.

B is a pressure head for the electrodes. In some cases the head is designed so that the pressure can be rapidly varied between two values, thereby making it possible to use a squeeze pressure (prewelding pressure or a forge pressure (postwelding pressure) different than the welding pressure.

C, the electrodes, are made from copper or copper alloys and usually water cooled.

D, controls for the various steps of the welding process.

The problems of resistance welding control may be divided broadly into three parts.

1. Start and stop control of the current to the welder.
2. Control of the amount of current that flows.
3. Control of the welding time and electrode pressure sequence.

All three of these basic control problems are handled electronically which has resulted in giving resistance welding incomparable speed and exactitude and extended its application to practically every metal fabricating industry, both for subassemblies and for final assemblies. So precise is the control by electronics that even materials such as aluminum, stainless steel, alloy steel and magnesium (once considered nonweldable) are now welded on a mass production basis. It is possible to weld two $\frac{1}{8}$-in. strips of stainless steel by shooting through them a current of approximately 15,000 amp. for a fifth of a second. Alloy steels can be welded, grained refined and tempered without removing the electrodes from the work.

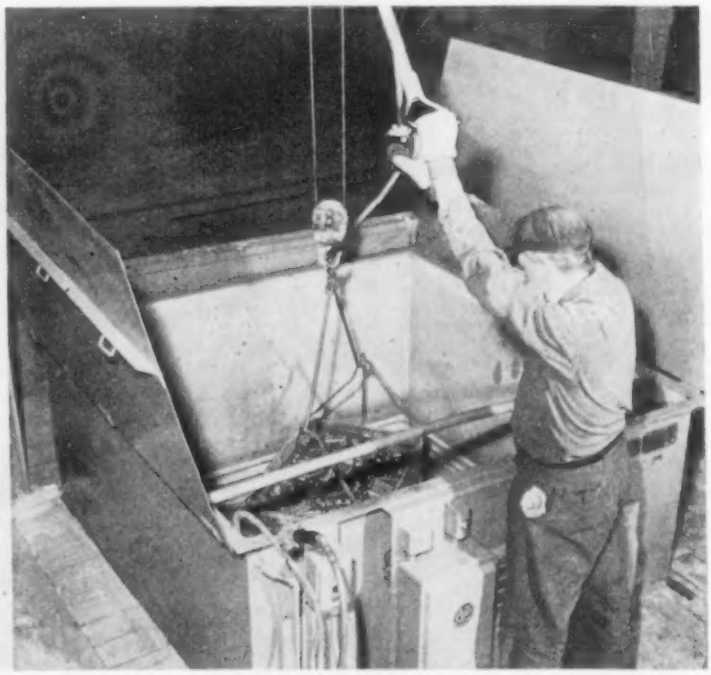
Silver Brazing by Induction Heating*

By J. P. "Mike" Weed†

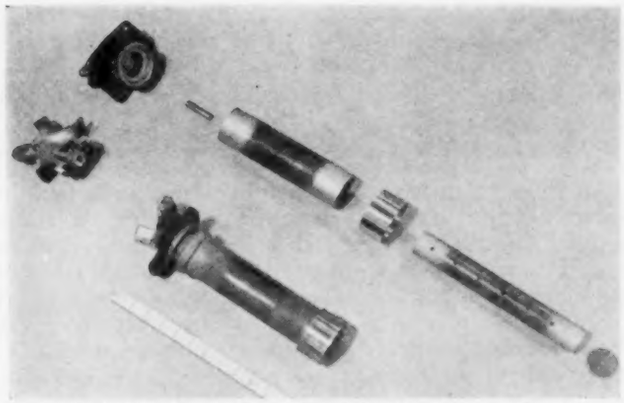
EARLY in 1944 increasing demands were made upon production departments manufacturing welded assemblies for aircraft. The extreme shortage of skilled welding operators was acute. Therefore it became imperative that something be done to increase production without an increase of personnel. Several approaches to the subject of production were immediately put under observation. Among those was the use of silver brazing alloys to substitute for older standardized methods. Casual observation immediately pointed to several assemblies where the use of silver not only increased production but actually improved both the appearance and strength of the job while reducing the weight. More intense study of the possibilities of the use of silver brazing in aircraft assemblies resulted in the redesign of some assemblies and the procurement of additional equipment for automatically or semiautomatically controlled heating. As the use of these controlled heating devices has become more general the field for the use of silver brazing alloy in aircraft has be-

* Presented at the January 18th Meeting, Los Angeles Section, A.W.S.
† General Welding Foreman of North American Aviation, Inc.

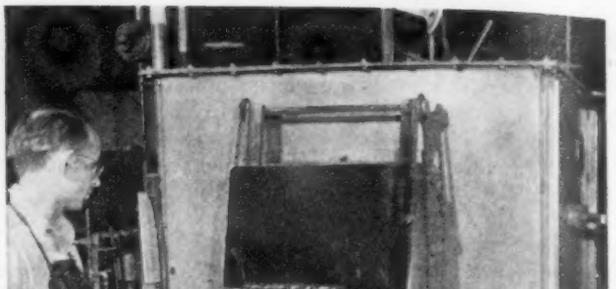
Removing Flux on Completion of Silver Brazing with Hot Water Bath at 180° F.



Removing Grease and Oil from Steel Parts to Be Silver Brazed with Vapor Degreaser



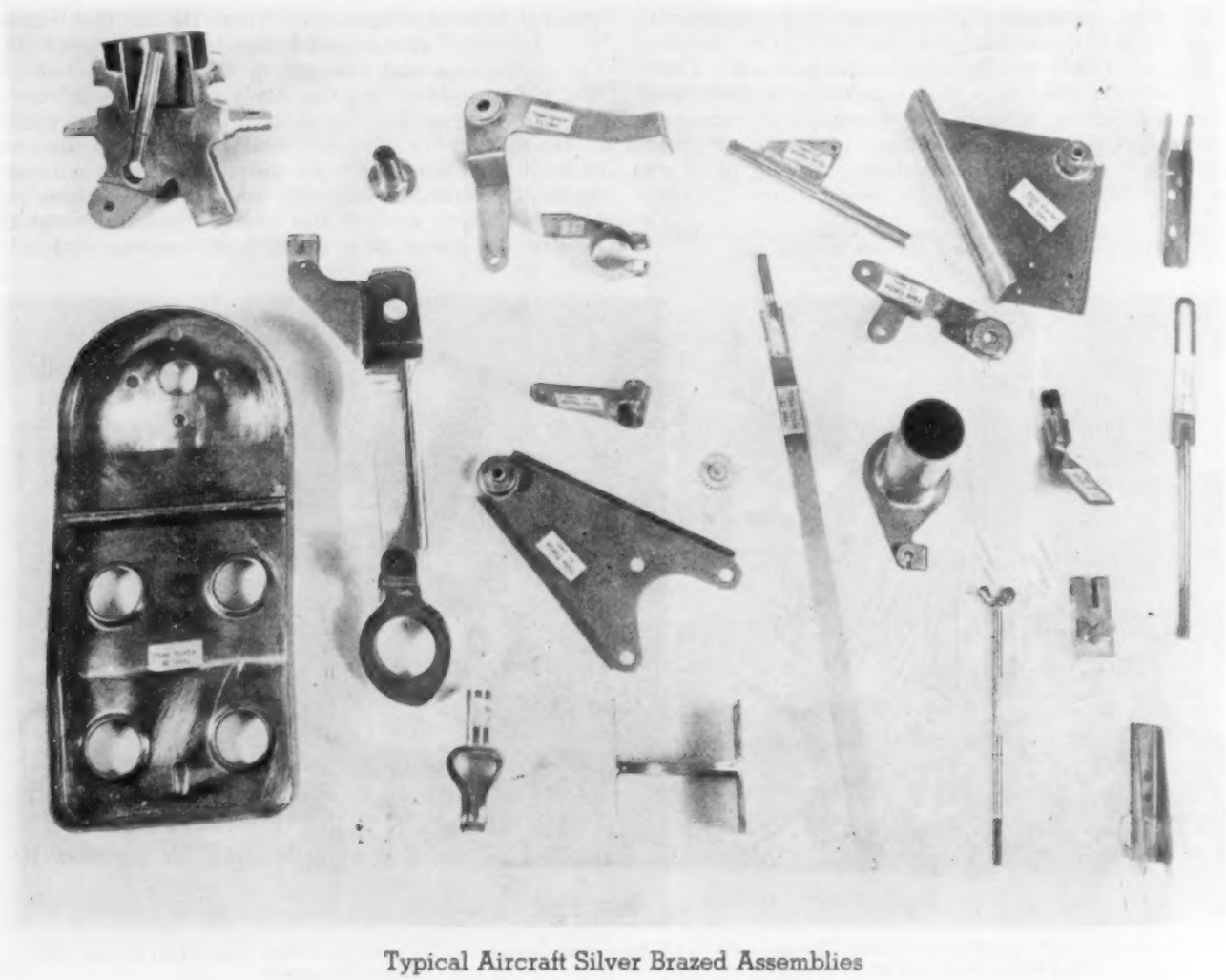
Exploded Hydraulic Tail Wheel Assembly Silver Brazed



Assemblies and Preplaced Silver Alloy Prior to Entering Electric Furnace

come almost unlimited except for certain highly stressed members.

We found that the high degree of ductility and malleability of silver brazing alloys gives two important advantages. First, joints made with them provide great resistance to vibration and severe shocks. Second, assemblies can be fabricated easily into a wide variety of sizes and shapes, thus making it possible to obtain joints in the form most convenient and economical for the different conditions under which they are used. They can be applied to any type of joint. Although scarf, lap and sleeve joints on sheet metal, piping and tubing have the advantage of providing a greater bonding area than butt or seam joints, experience has shown that the



Typical Aircraft Silver Brazed Assemblies

strongest joints are produced with a minimum amount of clearance. The free-flowing characteristics of silver alloys make it possible and advantageous to provide closely filled joints that require a small amount of silver brazing alloy. Properly fitted joints are economical in the use of silver alloys; and the neatness of these joints, which in many cases are practically invisible to the naked eye, is often a decided advantage where plating, painting or other processing is required.

Silver has many extraordinary qualities. When melted it is extremely fluid. It is also one of the most ductile of metals, Its electrical conductivities are higher than copper-106 as compared to 100. When alloyed with other metals, copper, for example, silver unites to form compositions having flowing temperatures lower than either of the individual metals.

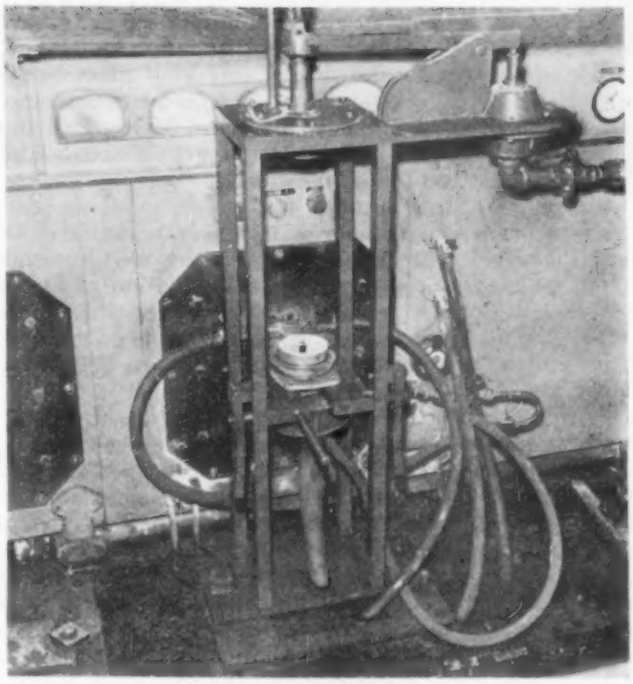
The extreme fluidity of melted silver base brazing alloys gives them the ability to penetrate quickly into narrow openings. Capillary action spreads them evenly over the surfaces to be joined where they diffuse into metal surfaces and form a bond which is practically indestructible. Low working temperatures and rapid penetration thus make silver brazing an exceptionally fast method of joining metals.

The ductility and strength given by silver are also closely related to their flowing qualities. Silver brazing alloys in themselves, as previously mentioned, are strong, having tensile strengths of from 40,000 to 60,000 psi., but when thin films penetrate into a joint and bond with metals, they have the unique ability to give strength far beyond their basic strength.

Oxyacetylene Application Silver Brazing

It is of the utmost importance that silver brazing joints be properly designed. The correct design is mainly a question of the type of joint to use and the clearances required. Of the three types of joints in general use: butt, scarf and lap or shear, the lap or shear type joint is the design generally recommended although the others can be used satisfactorily under some conditions.

Lap type joints are the most satisfactory and are generally used because any desired factor of safety can be incorporated by varying the lap shear area. This type of joint offers better resistance to corrosion due to the small area of brazing alloy exposed. Joints can be held in place readily, and, in joining flat parts, a little pressure will insure complete bonding. In shear joints,



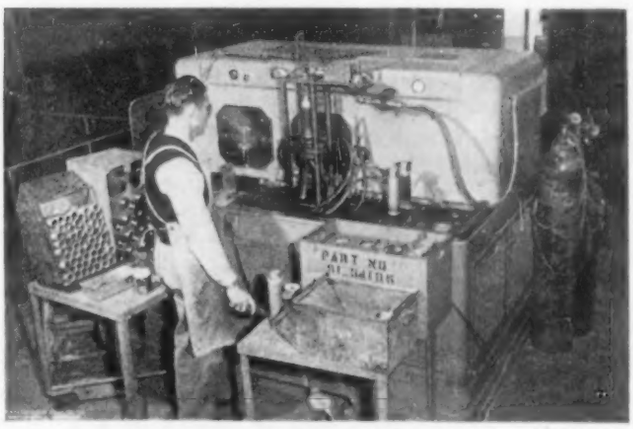
Induction Silver Brazing Jig

which include tubular members, pressure cannot be exerted and correct clearances must be maintained to insure proper capillary action.

In setting up procedure for production, in silver brazing, there are five simple but important steps to be observed:

1. Clearance.
2. Clean metal.
3. Proper fluxing of parts to be joined.
4. Locating device or jig.
5. Heating method.

Clearances for silver brazing are important. Metal to be joined should fit closely enough to permit the effective working of capillary action. From experience in the laboratory and field, it has been found that clearances of from 0.001 to 0.006 in. on the flat or tubular work give the strongest and soundest joints. Clearances which are too close cause bare spots where brazing alloys are unable to flow. Enough clearance should be allowed to make certain that there will be a film of brazing alloy throughout the joint. When brazing alloys are preplaced in the form of thin inserts, a little pressure on the joint while heating forces out excess alloy and leaves a film that takes care of irregularities in joint surfaces.



Induction Unit Set Up for Silver Brazing

We have found that it is an absolute necessity to have the surfaces of the joint clean and protected with flux. Grease, oxides, scale and dirt of any kind must be removed, and extra care taken in this regard will eliminate many of the causes of defective joints. Mechanical and chemical cleaning can be used either together or individually as required to produce cleanliness.

The temperatures required for the use of silver brazing alloys will cause the oxidation of the surfaces of both the silver and metals being joined and provision should be made for preventing this oxidation as far as possible and for the removal of any oxides which may form. To do an effective job, a brazing flux should be entirely fluid and active at a temperature below the flowpoints of the brazing alloys with which it is used. A fluoride type of paste flux beginning to fuse at 800° F. should start dissolving oxides immediately. At 1100° F., it should be a thin colorless active fluid dissolving all refractory oxides including the chrome oxides rapidly and thoroughly. The use of a flux as a temperature indicator is strongly recommended, particularly where it is difficult for the operator to determine when the metal parts have reached the temperature of approximately 1200° F. as in the oxygen acetylene torch applications.

Where study and consideration are given to the jigging of the parts to be silver brazed, uniformity of results can be expected. Particularly is this true where production is a prime consideration. As often is the case where furnaces are used or where a number of parts are to be brazed simultaneously, the jigging of all parts to be brazed is performed by operators trained for this job and then turned over to the operators who handle the heating of the metal. Jigging by spot-welding, staking and riveting are the three most commonly used methods in furnace and dip brazing. In torch and induction brazing, use of a suitable jig with properly set holddown clamps is made most frequently.

The heating method will be predicated on several factors: the type of work, volume of products and the availability of equipment at hand. Since most shops have the oxyacetylene torch equipment, it is natural that in venturing into the new field of silver brazing, the equipment at hand be used. As confidence in results is established, and if the work warrants speed in production, other methods of bringing metal to temperatures of approximately 1200° F. are investigated.

Furnaces heated by oil, gas or electricity using either the batch principle or conveyors are conductive to rapid production of small parts in large volume. Parts to be brazed are fluxed and silver alloy preplaced before going into the furnace. Temperature of the furnace should be in excess of the flow point of the alloy for fast heating.

Incandescent carbon heating lends itself to the silver brazing of small parts. The part to be brazed is placed between the electrodes and there held in position by pressure. Insulated electrical parts can be joined in this manner without fear of damage to insulation. Hand feeding of the silver alloy or preplacing of same depends upon the job.

Resistance brazing responds to the ingenuity and equipment available to production management. Those who have used this method of heating parts to be silver brazed have found an answer to heavy production on types of work where it is practical to preplace the alloy.

Dip brazing is the employment of the metal bath or the chemical bath. The metal bath requires that parts be held in brazing position and dipped into a molten bath of brazing alloy. Brazing of this kind is used mostly to join comparatively small work. Crucibles for holding the molten alloy may be heated by gas, oil or electricity.

The chemical bath also offers the advantage of fast heating and as does the metal bath, provides protection from the oxidizing effect of the atmosphere. The salt mixtures used are heated in a suitable furnace. Work must be supported in jigs and the brazing alloy preplaced. Brazing temperatures are easily controlled. The size of the salt bath depends upon the size and weight of the work. Baths should be large enough to show no appreciable temperature drop when the parts are immersed.

The use of induction heating in silver brazing is the most modern and satisfactory method from the aircraft manufacture viewpoint. Induction heating as its name implies is produced by inducing a high frequency current in the part or parts to be heated from a water-cooled copper or brass coil. Current for the coil can be supplied either by motor generator, spark gap or vacuum tube oscillating equipment. The frequency ranges from around 10,000 to 450,000 cycles per second. Several advantages in using induction type heating units are that, normally, very simple jigging for holding parts is needed, and tooling, in the form of copper coils for the heating unit, is inexpensive and requires a very short time for manufacture and installation. Production rates, for "batch lots" as commonly set up in aircraft manufacture, are very rapid. Changeovers in production from one part or assembly to another require only a very few minutes. Control of volume and location of heat is positive and variable. Once the time settings are properly set, it is possible for even the most inexperienced labor to operate the unit without variation.

Primary disadvantages in the use of induction units are initial high costs. However, where a large volume of variable types of heat treating and silver brazing assemblies is required, use of induction heating will be found to be economical and versatile, overcoming the drawback of high initial cost and paying the cost in a very short time.

Cost of silver brazing by any of the above methods has purposely been avoided. However, a few comparisons of cost using silver alloys rather than other methods of manufacture indicate that, although the initial cost of silver alloy is high in comparison with other materials, there is an appreciable saving both in assembly and in the aligning preceding brazing. Furthermore, the fact that skilled operators are not required makes the cost of silver alloys as a manufacturing material in the completed assembly almost negligible. This cost always varies according to the clearances allowed in the setup but extremely small amounts of silver alloys are always used in comparison with the older manufacturing methods. For example, one assembly, a retractable landing gear, formerly using 6 oz. of weld electrodes has been converted to silver brazing and requires but 1/3 oz. of silver alloy.

Weight reduction, while maintaining high strength factors, is unfolding a new field to low temperature silver brazing. Castings with complicated machine operations are being surveyed for replacement with silver brazed parts. As often is the case, metal and stampings can be joined with silver, reducing and frequently eliminating machining operations.

The armed forces have again informed industry of their requirements. Many of our skilled operators now in aircraft manufacturing will be called. Equal or greater production schedules will be required. Silver brazing can be of great assistance in overcoming a new production bottleneck. It is now very apparent that the uses of silver alloys in producing lighter, stronger, better appearing assemblies, requiring less time, are on the threshold of very rapid expansion in aircraft manufacture in the near future.

Spot-Welding Machines for Heavy Gages of* Ferrous and Nonferrous Metals*

By Mario Sciaky†

MOST applications of resistance welding seem to be found in assemblies made of 12- to 26-gage clean mild steel. In this group can be included the fabricating and assembling of automobile bodies, ventilating systems and home appliances; and even most of the manufacturing of railroad passenger cars. Most aluminum parts welded in airplane construction, on the other hand, rarely exceed 0.080 in.; in fact, 90% of the welds are made on thicknesses not exceeding 0.064 in. This also is generally true in the welding of other alloys, such as brass, Monel, Inconel, etc.

Many types of welders have been developed for the welding of both ferrous and nonferrous alloys on the thicknesses from the foot-operated welder to the multiple head machine incorporating 60 to 100 electrodes. In order to weld materials exceeding 12-gage, however, many factors which affect the design of the welding machine had to be taken into consideration.

Design of Resistance-Welding Machines as Affected by the Welding of Heavy Gages of Steel and Aluminum Sheets

One of the factors which leads to the necessity for specially designed welding machines for use on heavy-gage ferrous alloys is in the nature of the surface of the materials involved. Thin gages of steel can be perfectly stamped when cold, the surface remaining clean. The heavy scale formed during the hot pressing operation of heavy gages affects the welding conditions. The use of welding in heavy gages also includes structural sections such as L, U, T, I, beams, etc. These sections are commonly hot rolled and covered with heavy rust and scale.

The power demand increases with the thicknesses to be welded due to the diameter of the weld, which increases in proportion to the material. It can be said that the volume of the weld is the actual factor which causes an increase of the power demand, approximately in proportion to the cube of the thickness.

When welding steel, however, the instantaneous power demand is reduced to a certain extent because of the longer welding time used. In the case of aluminum and copper alloys, the welding time must remain short, the power demand is surprisingly increased, necessitating in the case of stored energy exceptionally heavy machines for apparently moderate thicknesses. As an example, the weight of a stored energy machine capable of welding $^{3}/_{16}$ in. plus $^{3}/_{16}$ in. aluminum reaches the very impressive value of 36,000 lb.

The magnetic properties of steel also affect greatly the power demand and the power factor of the welding machine. Consequently, when a quarter inch thick sheet is inserted between the arms of the welder, the inductance of the secondary circuit is drastically changed. The machine settings, therefore, must vary according to the amount of metal introduced between the arms.

The electrode pressure also has a complex function in the welding of heavy gages of both steel and aluminum. This is due to the surface conditions, as mentioned above, and in many cases to the spring effect resulting from poor fitting.

Moreover, many of the problems result from special cooling of secondary circuits from the type and contour of the electrode tips, from the heavy weight of the assemblies, etc.

We will endeavor in this paper to outline the solutions adopted in designing welding machines which take into account these different conditions.

Welding of Scaly Steel with Conventional Machines

As mentioned above, scale and rust on heavy steel plate and structural sections create high contact resistance between sheet and electrode and between sheets. This condition restricts the number of contact points allowed for the passage of the welding current and in certain cases wholly prevents any current from flowing in the secondary circuit due to insufficient electromotive force to break through the scale.

The high current density on the contact points develops local metal ignition, with subsequent projections of burned material. The excessive temperature resulting between electrodes and material on the mentioned points creates heavy pickup with rapid deterioration of the electrodes. The projections of metal, on the other hand, which originate from the contact surface between the sheets, create cavities in the welded nugget which reduce the quality of the produced spot weld. All these conditions have encouraged sand blasting and pickling previous to welding, but have also limited the extensive use of spot welding in the field of application.

Variable Pressure Cycle

The electric resistance of the contact between electrode and sheet and between sheets can be represented roughly by

$$R = \frac{\rho}{S} \times \frac{K}{P}$$

* Presented at the Twenty-Fifth Annual Meeting, A.W.S., Cleveland, Ohio, Oct. 16 to 19, 1944.

† Sciaky Bros., Chicago, Ill.

where K is the constant characterizing the surface condition, ρ is a specific resistance of the material, P is the force applied by the electrodes and S is the contact surface area.

This shows that an increase of P will result in a proportional reduction of R, due to an expansion in the number of contact points, and a better chance for the current to flow through the joint. It was found, however, that in order to prevent local burning of the material, it was necessary to substantially reduce the current in order to limit the temperature rising at the contact points. The value of the temperature reached in this condition at these points is sufficient to burn the oxide only; thus decreasing rapidly the resistance of the contact points and making possible the passage of a much higher current necessary for the welding operation. If the welding procedure is interrupted at this point, a simple examination of the surfaces would show the disappearance of the oxide scale and a perfectly clean surface ready for welding on any standard welding machine.

The welding sequence that follows this first operation is identical to that of any standard machine, the pressure being reduced to a standard value and the current raised to a sufficient intensity for the welding operation.

Another necessity of having an unusually high pressure during this "squeeze time" lies in the desirability of having a good fit between parts before starting the current. As mentioned in the first part of this paper, the parts have a tendency to spring back due to their natural rigidity, and normal welding pressure would not be sufficient for a good contact.

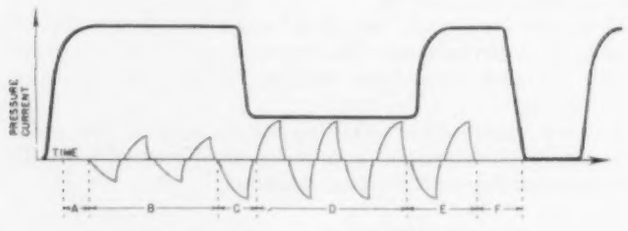


Fig. 1

In some cases, as mentioned above, the contact resistance is sufficiently high to prevent the start of the preheat current due to the lack of adequate electromotive force. An automatic system is incorporated in the machine which provides a higher voltage between the tips at the beginning of the passage of the current. Provisions are made to drop this voltage to the preheat value as soon as the current is established.

During the welding period, the nugget formed by the molten metal, due to its expansion, is of larger volume than the original metal. The nugget thus has a tendency to force back the walls surrounding it. If the electrodes exert an excessive force, the nugget will be able only to push the lateral side of the walls, causing sheet separation. It is therefore advantageous to let the nugget expand in a vertical direction by allowing the electrodes to "give up" elastically under the effect of the metal expansion.

Before the current is interrupted, however, an increase of the welding pressure causes the upper and lower walls to follow up the shrinkage of the nugget, preventing internal coarse structure and cracks. In fact, while the crystals are forming during the cooling period, the shrinkage of the nugget to its original volume tends to separate the molten metal from the solid, thus tending to

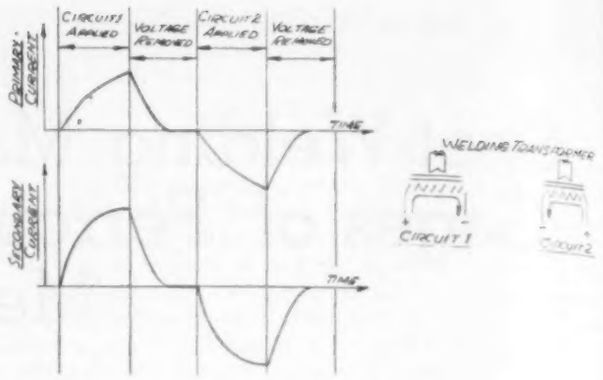


Fig. 2

create cracks and internal stresses. An increase of electrode pressure will push back the upper and lower walls surrounding the nugget, causing them to follow the shrinkage.

The variable pressure cycle, as described above, may be condensed as follows:

High pressure-high electromotive force for break-through of excessive resistance, allowing initiation of preheat current;
High pressure-low current for a full burning of the oxide, conservation of the electrodes, prevention of cavities;
High pressure-high current for fitting of material;
High current-low pressure for high efficiency of the welding current, prevention of sheet separation;
High current-high pressure for quick follow-up and prevention of coarse structure and internal cracks;
High pressure-no current for forging period (Fig. 1).

This same sequence is applied to the welding of aluminum gages ranging from 0.032 to 0.187 in. Here, however, the surface condition needs to be corrected by etching previous to spot welding, since the preheating method outlined above does not show satisfactory results on aluminum. Preheat and variable pressure are maintained; break-through electromotive force is not needed.

Three-Phase Welding Machines

As we have outlined above, the power drawn from the line increases very rapidly with the thickness of the

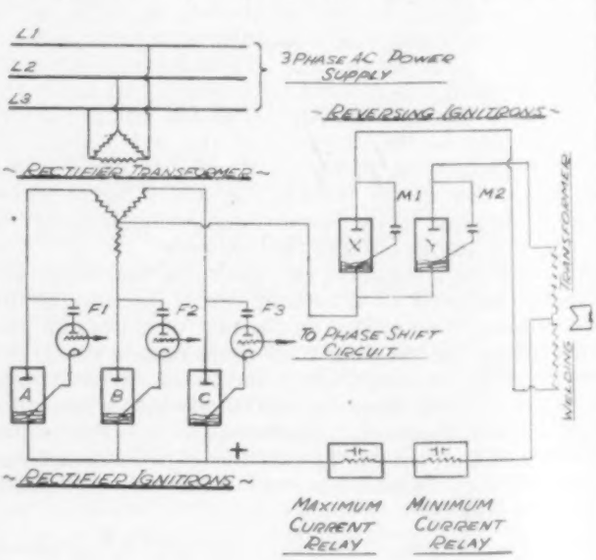


Fig. 3

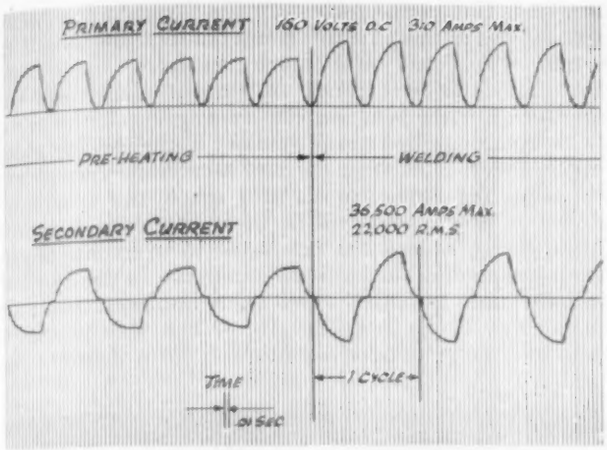


Fig. 4

material to be welded. The use of single-phase machines for the welding of heavy gages unbalances a three-phase line and since most industrial installations have a three phase power system, these machines cause a serious disturbance to the power supply. These constitute a heavy reactive load to the power system due to a high inductance of the secondary welding circuit, the inductance being determined by the throat depth of the machine and by the distance between the arms.

Since this reactance is much larger than the secondary resistance, it determines the impedance and the power factor of the welding machine, hence these machines operate at very low power factors (for large machines, less than 30%) and draw very highly reactive currents from the supply system.

For welding machines operating at frequencies of 50 to 60 cycles, the conductivity of the secondary circuit is limited by the skin effect in the conductor. It is a well-known fact that in alternating current circuits most of the current flows on the surface of the conductor, the depth of the current penetration decreasing with increasing frequency. Because the values of welding current necessarily obtained may be very high, it is desirable to reduce the secondary resistance to the minimum value, a factor which cannot be easily accomplished on 50- or 60- cycle machines because of this skin effect. It is not possible, therefore, to reduce the power demand (kw.) of the machine below a value which is determined by the frequency of the applied voltage.

A conventional single-phase alternating-current welding machine has, therefore, three distinct limitations:

1. It causes unbalanced power distribution on three-phase systems.
2. It causes a very high kva. demand at exceedingly low power factors.
3. It causes a high power demand (kw.) from the power system.

These limitations naturally constitute a serious problem to both the users of welding machines and to the power supply companies. It is frequently necessary for welding machine users to build additional power installations which, of course, makes the cost of operation very high. In fact, it is often impossible for machines built for spot welding heavy thicknesses of steel to be used since there may not be provision for adequate power supply. It is desirable, therefore, that a welding system be devised which would operate in such a way that:

(*a*) it will constitute a three-phase balanced load;
(*b*) it will operate at near unity power factor;
(*c*) it will decrease the kva. demand.

By using such a system, it will be possible to:

(*a*) reduce the cost and equipment of the power installation;

(*b*) reduce the cost of operation of the welding machines.

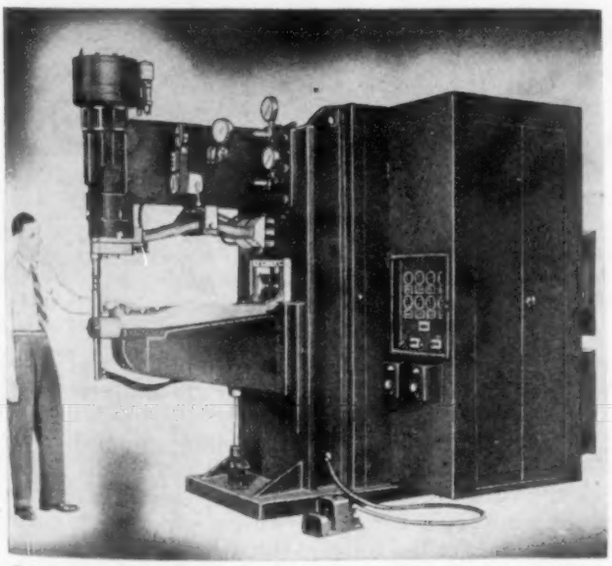


Fig. 5—Machine Type PMCO.5S-1, Capable of Welding Two Thicknesses of $^{5}/_{16}$ Alclad 24 ST

This type machine weighs 36,000 lb. and is supposed to be the heaviest spot welder of aluminum ever built.

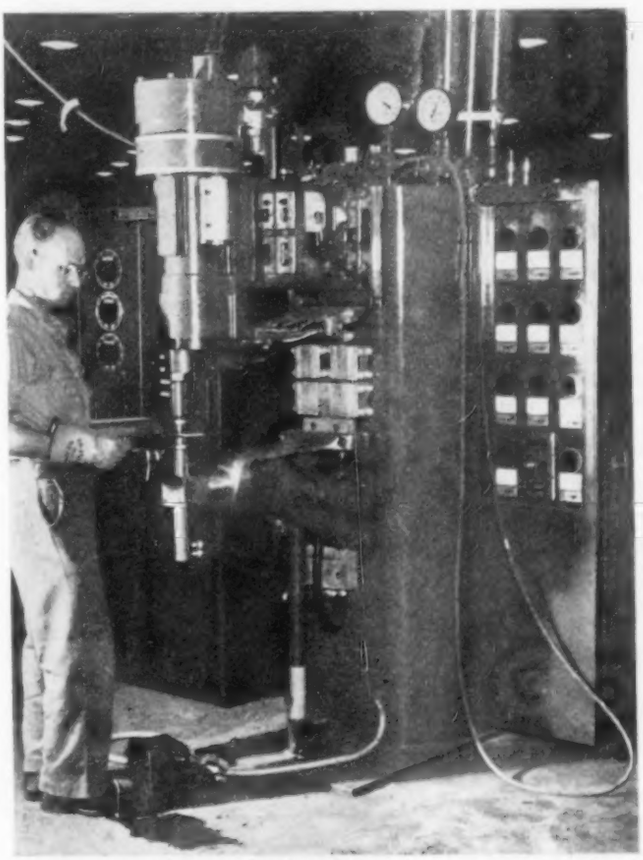


Fig. 6—Machine Type PMCO.2T-2, Operating on Three Phase

This machine is in operation at Douglas Aircraft Co., Inc., El Segundo plant, and is designed for welding alloy steel of armor plate up to $^{1}/_{4}$ in. plus $^{1}/_{4}$ in.

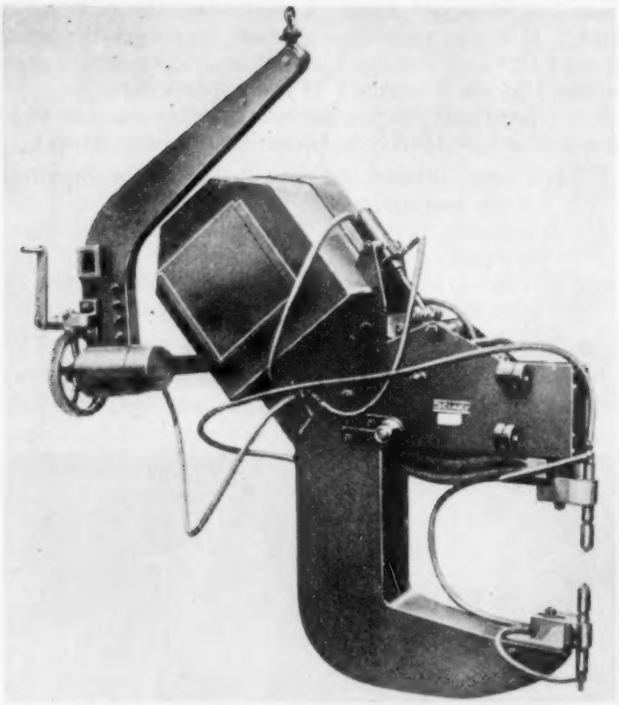


Fig. 7—Machine Type PMA 490 Designed to Be Suspended from Crane, and Can Be Tilted on Different Planes

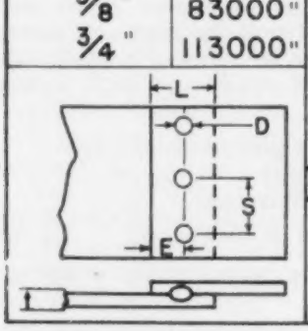
Capable of welding up to $^1/_2$ in. plus $^1/_2$ in. rusty, scaly steel. The controls are separate and can be mounted either on the crane or on the wall.

Principle of Operation

If a d.c. voltage is applied across the primary winding of a single-phase, transformer, the resulting current flow will create, in the iron core, a magnetic field of increasing value up to the point of saturation. This field variation will induce an electromotive force and the subsequent current in the secondary circuit will increase in value along a curve, the shape of which is governed by the parameters of the secondary circuit. At the instant when the secondary current reaches its maximum value, the ratio of primary to secondary current is the same as the turn ratio of the transformer windings. If the primary circuit is interrupted, the secondary current will decay and reach the zero value rapidly. This rise and decay of current constitutes one impulse. For the next impulse a reversed polarity of the d.-c. source is applied to the primary of the welding transformer, so that the primary and secondary current will rise along the same curves and reach the same magnitudes as before, but will be in the opposite direction. This reversed polarity is necessary to overcome the effect of the residual magnetism remaining in the iron core from the first impulse. Two such impulses constitute one current cycle (see Fig. 2). When this process is repeated a large number of times, a form of alternating current is generated in the secondary circuit and is used as a welding current. The magnitude of the secondary current impulse obtained after any given time interval is directly proportional to the voltage applied to the primary of the welding transformer. This is accomplished by means of a tap switch on the rectifier transformer, and often combined with a phase shift circuit applied to the control tubes in the rectifier.

The duration of each impulse and the time interval between impulses are controlled by the selection of proper sequencing timers turning the current impulse on and off.

STEEL		ALUMINUM	
THICKNESS	SHEAR	THICKNESS	SHEAR
$^1/_8$ IN	6100 LB	081 IN	1800 LB
$^1/_4$ "	17000 "	125 "	3000 "
$^3/_8$ "	33000 "	156 "	4500 "
$^1/_2$ "	62000 "	187 "	6500 "
$^5/_8$ "	83000 "		
$^3/_4$ "	113000 "		



t = THICKNESS OF MAT'L.
S = MIN. SPACING.
D = DIAMETER OF SLUG.
E = DISTANCE FROM CENTER OF WELD. TO EDGE.
L = MIN. OF LAP.

ALUMINUM	STEEL
D = 4t	D = 2t + $^1/_8$"
S = 15t	S = 12t
E = 6t	E = 5t
L = 2E	L = 2E

Fig. 8

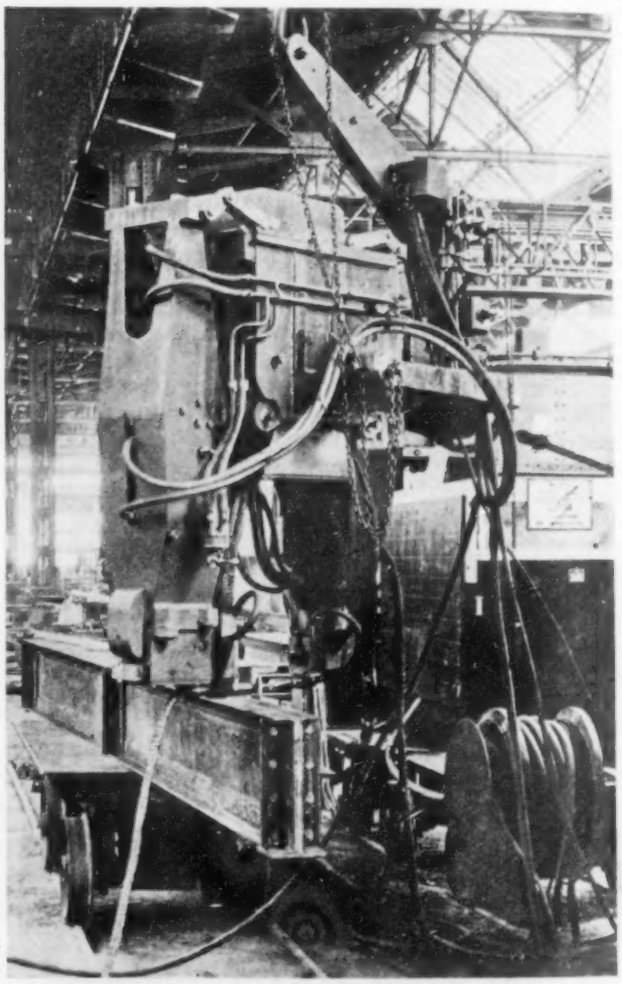


Fig. 9—Machine Type PMC3, for Operation from Crane

This machine was built in France and was installed at Widkovicze in Czechoslovakia. Capable of welding $^1/_2$ in. plus $^1/_2$ in. rusty, scaly steel. Can be tilted on three planes and as shown in the picture the machine is in the process of spot welding a prefabricated steel beam.

Method of Operation (Fig. 3)

The direct-current power supply used for this type of machine is an ignitron tube rectifier, which may either be separate or built into the machine as an extra cabinet on the left-hand side. The latter system is preferable because so much of the control circuit is integral with the rectifier. It is possible to operate the machine at any desired voltage providing the welding transformer is designed accordingly. This transformer is of the standard single-phase type, but has its primary winding center tapped.

The negative side of the rectifier or the center point of the star connected rectifier transformer secondary is connected to the cathode of two reversing ignitron tubes. The anode of one of these ignitrons is connected to one side of the welding transformer primary; the other one being connected to the opposite side. The center tap of this transformer is connected to the positive side of the rectifier or to the cathodes of the rectifier ignitrons. The sequence is arranged in such a manner that voltage impulses from the rectifier cause current to flow alternately first through one ignitron to one side of the primary of the welding transformer returning through the center tap, then through the other ignitron to the other side of the welding transformer primary (see Fig. 4). This causes a reversal of direction of the applied primary voltage and the resulting secondary current without actually changing the polarity of the rectifier output. The initiation and interruption of the current impulses from the rectifier are accomplished either by closing and opening the igniter circuits by means of a mechanical relay, or by means of grid-controlled thyratron tubes. Although the sequence can be either fully electronic or composed of a system of electromagnetic relays, most of the latest model machines have been fully electronic.

It will be noted that the rise to the peak of the secondary current in this type of machine is much slower than that obtained in the single-phase 50- or 60-cycle unit. This naturally reduces the skin effect considerably and effectively causes a higher conductivity of the secondary circuit, thereby lowering the kw. demand. Because an equal amount of current is drawn from all three lines of the power supply, there is practically no unbalancing of the phases. It has been found that the power factor per phase for this type of machine runs very close to 85% as against 25 or 30% for single-phase welders. Because of the comparatively slow rise to the peak of the welding current in this new system, the problem of obtaining satisfactory welds, particularly on steel, becomes less critical. The sudden rise to the peak in one-fourth of a cycle for single-phase machines causes most of the current to flow through the periphery of the welding electrodes, which in turn causes intense local heating, possible spitting, and electrode pickup. The

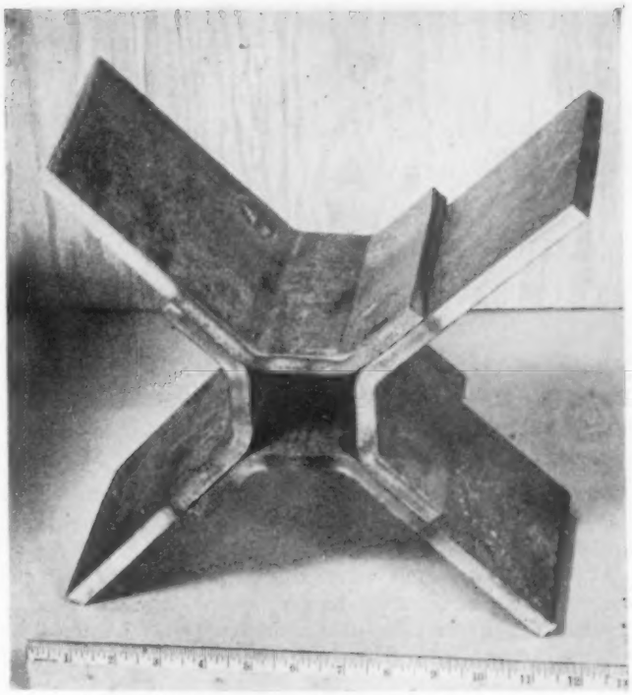


Fig. 11—Spot-Welded Assembly Composed of $^{5}/_{8}$ In. plus $^{5}/_{8}$ In. Rusty and Scaly Steel

Cross section shows the structure of the welded nuggets.

Fig. 10—Steel Construction Composed of Spot-Welded, Prefabricated Parts, Assembled by Rivets on the Field

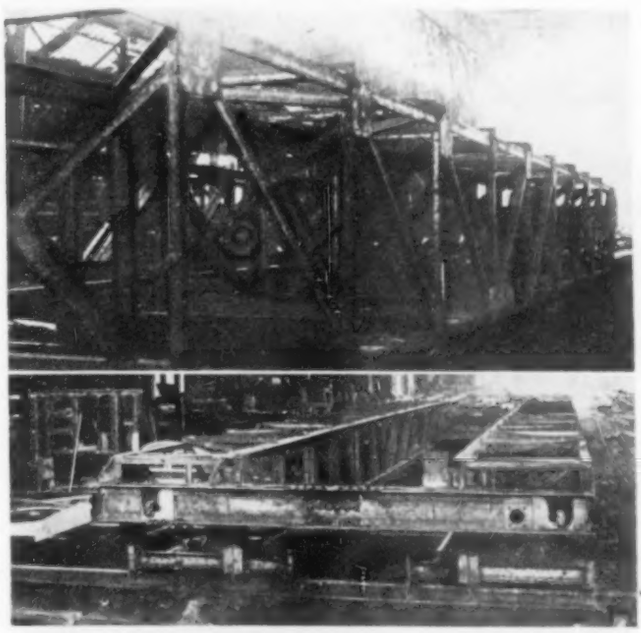


Fig. 12—Steel Crane of 6 Tons Carrying Capacity and 50-Ft. Span

All stressed components are spot welded, except for the lateral troughs and horizontal webs which are arc welded for reasons of work accessibility and water tightness.

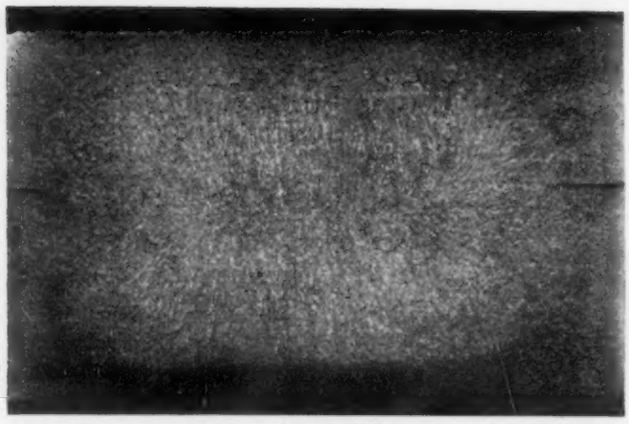


Fig. 13—Hot-Rolled Scaly and Rusty Low-Carbon Steel. $^{3}/_{16}$-In. Angle Iron, $^{1}/_{4}$-In. Plate

new system with its slow rise automatically tends to eliminate this difficulty.

When welding steel, particularly in the heavy thickness, it is usual practice to employ a large number of impulses. Part of this total weld time may be at a low voltage output from the rectifier so that the impulse peak in the secondary circuit is below that required for welding, and is classified as a preheat. This is then followed with a high voltage output giving a welding current which may again be followed with another lower voltage, causing an annealing current.

Another method of welding, particularly when this new type machine is applied to seam welding, is to use one impulse per weld. This requires, in general, higher pressures and automatically is limited to use on thinner materials and aluminum alloys. For the latter case, it has been found necessary to use only one impulse, but to vary the voltage during the impulse to obtain preheat and tail current. Of course, this requires extremely accurate electronic control as, for example, one impulse may consist of 0.04 sec. at low voltage, 0.03 sec. at high voltage, followed by 0.04 sec. at lower voltage. Machines operating under this principle are mainly applied to the welding of ferrous metals, stored energy usually being applied for the welding of aluminum alloys.

Stored Energy Welding Machines for Heavy Gages of Aluminum

An appreciable number of magnetic stored energy machines capable of welding up to $^{3}/_{16}$ in. plus $^{3}/_{16}$ in.

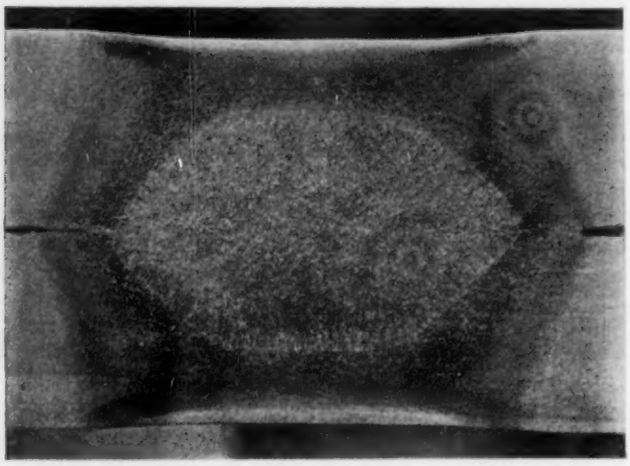


Fig. 14—0.375 In. + 0.375 In. Clean Mild Steel

aluminum have been in operation for over three years in various plants throughout this country. The secondary current obtained by this method can reach values ranging up to 130,000 amp., but their duration does not exceed 4 to 5 cycles. The shape of this welding wave lends itself readily to the welding of aluminum, but since longer welding times are required for welding steel, some method as that explained above had to be devised. One of the greatest difficulties in obtaining the right shape of wave for welding aluminum lies in the development of long enough times and not too rapid decay of the welding current. The amount of iron and copper, the number of windings of the primary and secondary had to be carefully calculated for this purpose (see Fig. 5).

Welding Machines for Heavy Gages of Steel (Fig. 6)

The welding of heavy gages of steel which can easily be handled is done on pedestal machines, as in the case of any standard spot welder. The weight of the parts, however, limits this method of welding, inasmuch as it increases very fast due to the thickness involved. Portable guns are impractical due to the size of cables that would be required and the losses that would consequently occur. The machines that seem the most economical and practical resemble heavy pneumatic riveting yokes, and have the transformer mounted directly to the arms, as for a pedestal-type welding machine.

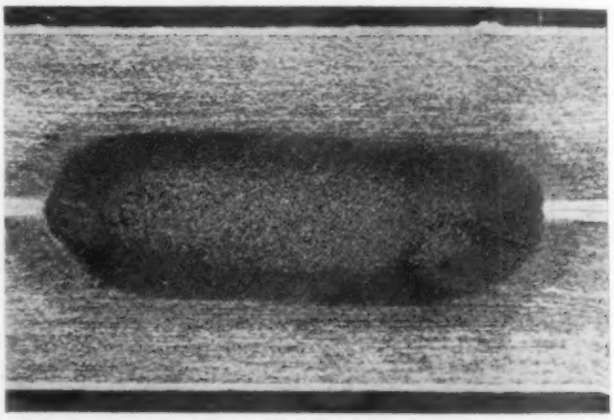


Fig. 15—0.187-In. + 0.187-In. Alclad 24ST

The suspension is designed to allow positioning on vertical and horizontal planes with all the intermediary settings. The machine is suspended from an overhead crane with the controls either mounted directly on the crane or on the wall (see Figs. 7 and 9).

In certain cases, the machines can rest on the floor and are mounted on trunions to permit a good alignment of the electrodes when the parts are tightly held on jigs.

All these machines incorporate variable pressure; preheat, welding, and postheat currents; and 3-phase control.

Spot Welds

The shear values, spacing, diameter of spot, etc., tabulated on this paper have been determined mainly experimentally. From the values found, simple formulas can be deducted (see Fig. 8).

The Use of Spot Welding as Compared to Arc Welding

Spot welding of heavy gages does not appear, at first glance, likely to present much competition to arc welding.

The initial investment for arc welding is obviously lower. Arc welding lends itself to a great variety of applications; above all, when the parts are of intricate shape and very large in size, as in shipbuilding. The technique of arc welding is, on the other hand, widely known and since many applications have already been found for its use, it is sometimes difficult to introduce the new method of assembly described in this paper. Arc welding very seldom requires flanges and therefore makes it possible to obtain lighter parts having the desired strength.

Applications for spot-welded parts become very beneficial, however, in the case of mass production of parts of simple shape when the construction requires flanges and overlapping surfaces. Spot-welded parts would be prefabricated in a shop and assembled in the field, either by rivets or by arc welding. This would be the case of special I-beams, structural elements for buildings, heavy stampings used in truck constructions, etc. (see Figs. 10 and 11).

Spot welding has been most successful as a mass production method and this should remain true also for the welding of heavy gages. It is quite difficult with this method of welding to use intricate electrodes. The parts must be of simple shape and easily accessible, since the pressures used will not allow excessive electrode deflection (see Fig. 12).

The use of heavy gages of aluminum has found a limit to a certain extent in the aircraft industry, due to restrictions in Army and Navy specifications. We presume that when aluminum is used for other purposes than aircraft construction in peacetime, the welding of heavy gages will find a natural field for new developments. (See Figs. 13, 14 and 15).

The field of application of heavy gages of steel and aluminum will certainly undergo numerous tests during the period of reconversion. Methods and machines exist and great efforts have been exerted to make them practical, flexible, and of economical application. Some machines are already in use and have brought success.

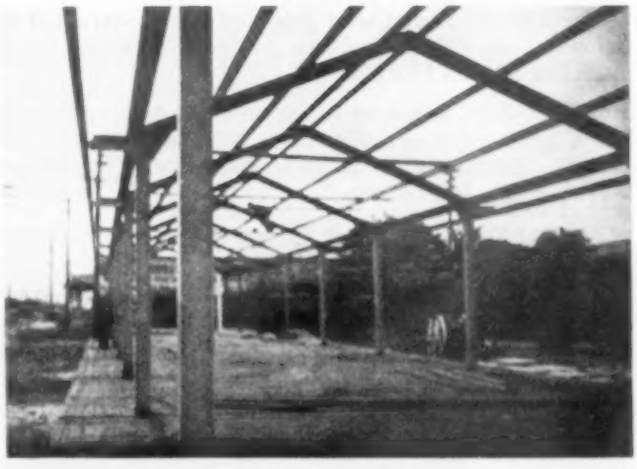
It is our belief that a very wide use of this process will follow, as has been the case for the light gages of steel and aluminum.

Welding Railroad Structures*

By T. H. Gardner†

IN the past 12 yr. or more, there has been considerable use of welding in the strengthening, or reinforcement, of bridge structures. This use has provided for the economical replacement of lost metal due to corrosion, or the placing of additional metal to increase the capacity of structures. Even though a structure is reconditioned with the live load stresses removed, some of the original members may have initial dead load stresses at the time that the new details are applied. This condition of unequal stress distribution in cross section of members may be intensified by unequal stresses set up in various components due to thermal changes due to heat from welding.

The accepted proper procedure of the welding may have to be deviated from in order to secure proper fusion and penetration of the parent metals of different characteristics. The original metal may have become pitted or reduced in section at the edges to the extent that it may be necessary to flame cut, or otherwise prepare the edges to properly receive the welding and secure a sound weld. Riveted connections which are inadequate may have to be supplemented by welding which may have to be ample to carry the entire stresses imposed. The conditions met in the reinforcement of structures may be far from ideal and usually are much more difficult than those met in the design, detailing, fabrication and erection of new welded bridge structures. In the use of welding for new structures the proper material can be specified. The selection of the shapes and plates, the preparation of the metal, assembly, fitting up, clamping, bolting and proper welding procedures can be used. The design and details can be made to more readily avoid secondary stresses.



Continuous Frame Steel, All Welded

Continuous Frame Steel Shed, All Welded, Miami

* Presented at the Twenty-Fifth Annual Meeting, A.W.S., Cleveland, Ohio, Oct. 16 to 19, 1944. In this paper the welding referred to is by Electric Arc Process.

† Structural Engineer, Florida East Coast Railway Co., St. Augustine, Fla.

All-Steel, All-Welded Double-Track Trestle, 250 Ft. Long, Built 1941, St. Augustine
Under Construction When Photographed

In cases connections may be greatly reduced in size, or even eliminated.

The Florida East Coast Railway has for the past 14 yr. reinforced several bridge and building structures by welding. Their experience in the use of this relatively new method indicated that the work was generally more easily performed, was more economical and that traffic could, in general, be more readily taken care of during construction than could be done in riveted work.

Our gradual conservative and economical use of welding in the strengthening of bridges, turntables and the alteration of structures, called our attention to the greater ease and feasibility we would probably encounter in building new all-welded structures, as compared with reinforcing riveted structures by welding.

The Florida East Coast Railway has constructed the following all-welded railway bridge structures for its main line used in Florida:

1933—50-ft. rolled beam span,* single track, Pacet Channel Viaduct, Key West Extension.

1935—Double-track bascule span, 50-ft., horizontal opening, Jupiter, Fla.

1937—Single-track, all-steel, open-deck trestle approaches to existing bascule span, 1200 ft. long, Stuart, Fla.

1941—Double-track, all-steel, open-deck trestle 250 ft. long.

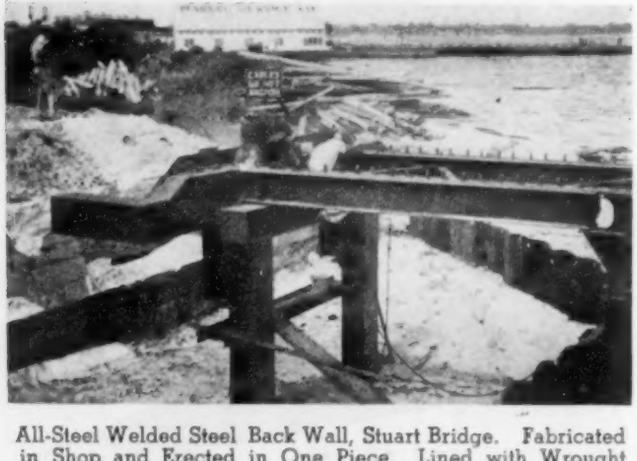
Our standard trestle construction for the past 8 yr. has been a one-ply 12-in. wide flange beam with stiffeners and end connection plates welded.

We have also used a fabricated steel cap, using a 12-in. tee section from a 24-in. I-beam split welded on a 15-in. channel laid flat with flanges turned down.

In all our welded work used, its use has replaced riveted work primarily because it developed to incur less initial cost. In welding construction we have usually sealed up the joints between abutting surfaces, to avoid the serious effect of progressive corrosion getting in between surfaces.

During the past 11 yr. more than 97% of the tonnage of new bridge construction has been done by arc welding, and less than 3% by riveting. The same ratio applies in reinforcement of structures.

* This span since incorporated in highway structure after Railway abandoned the Key West Extension.



All-Steel Welded Steel Back Wall, Stuart Bridge. Fabricated in Shop and Erected in One Piece. Lined with Wrought Iron Plates

Double-Track Bascule Span, Jupiter, Fla., 1935

Efficiency and Production Control of Training Personnel for Manual Arc Welding

By J. B. Arthur* and M. H. MacKusick*

TRAINING new personnel in arc welding is an important and a vital part of the production of all welded ships.

To us at Calship, training for welding work is a production job no different from that of any other production process. That is, we start out with raw material, process it, inspect and turn out the product.

This production process is necessarily large scale in scope in order to handle the personnel requirements of the yard.

Naturally in any large-scale production process, the system of processing the raw material is governed by the following factors (all related to the economics of time, finances, etc.):

1. Quality of raw material as received.
2. Use of the processed product:
   (*a*) Consumption.
   (*b*) Inspection standards.
3. Time for processing.
4. Equipment, materials, personnel, etc., used to convert raw material to end product.

In such large-scale production it is necessary to decide upon the method of process, with all details worked out, in order to obtain maximum production capacity. In the training of welders the method of processing is dependent upon the following factors:

1. Minimum production requirements for student welders after leaving "formal" training.
2. Money allocated to "formal" training of operators.
3. Operator qualification requirements.

The *ideal* method of processing is that one which would, in minimum time, turn out as a product, mechanics who would be able to do normal production work without further training. Practically this is never reached, since time and money force a compromise. The purpose of this paper is not to present the method of training or the qualifications of personnel so trained, but rather to present a system of efficiency and production control for the training process regardless of method or end point.

In order to know if a process is working efficiently, and in order to know the status of each unit in a production flow line, it is necessary to have a method of quantity and quality control as well as a method of determining quickly and with a minimum of effort the operating efficiency of personnel and equipment used in the work. All such controls are, in turn, used to improve quantity, quality and efficiency.

Presented below is the method of such controls, the use of the method and the results obtained by its use.

A person learns to arc weld by translation of a visual action into a manual action, i.e., by manual manipulation certain results are obtained which can be seen. There are probably in all cases several manual manipulations which might be used to give identical visual results. Therefore the time used in actual "burning" of electrodes and intelligent instruction is a possible source of measurement of production quantity, quality and efficiency.

We have devised a system of measuring "arc time" by use of consumed electrode count. This could have been done by use of "arc time" meters; however, by use of an electrode count we also licked the problem of housekeeping, full consumption of electrodes, full use of available man-hours in the rod distribution department, and incidentally eliminated the added equipment expense (installation and maintenance of "arc time" meters).

Electrode distribution cans were made up as shown in Fig. 1. These cans are all numbered and each student is assigned a specific can. Cans are also colored according to a shift code, thus facilitating the work of electrode distribution clerks in issuing electrodes to students.

Initially each student is issued 100 electrodes. Stubs are deposited into the can and the can is then returned to the rod room at the end of the shift or sooner if necessary. Stubs are counted and the count is entered on the form shown in Fig. 2.

The arc time is calculated from the following equation:

$$\text{Arc time (min.)} = \text{number of stubs} \times \text{standard burn-off rate}$$

(Burn-off rate is expressed in minutes required to burn off 12 in. of a 14-in. electrode.)

Extensive checks were made and the figures shown below are average and accurate for machine settings used in training. These rates are for A.W.S. Class E6010 electrodes.

Size of Electrode, In.	Minutes Required (2-In. Stub Loss)
1/8	1 min. 9 sec. (i.e., burn-off = 10 1/2 in. per min.)
5/32	1 min. 20 sec. (i.e., burn-off = 9 in. per min.)
3/16	1 min. 24 sec. (i.e., burn-off = 8 1/2 in. per min.)

To illustrate: Fifty 3/16-in. stubs (2-in. average length) were returned.

$$\text{Arc time (min.)} = 50 \times \frac{84}{60} = 70 \text{ min.}$$

This arc time is transferred to the card shown in Fig. 3.

The card shown in Fig. 3 is filled out further from time cards and test records. Calculations for efficiency are made as follows:

$$\% \text{ Efficiency} = \frac{\text{arc time (min.)}}{\text{training time (min.)}} \times 100$$

Thus, assuming a 9-hr. shift and full training with 50 3/16-in. stubs returned, the per cent efficiency would be as follows:

$$\% \text{ Efficiency} = \frac{50 \times \frac{84}{60}}{9 \times 60} \text{ or } 13\% \text{ (approximately)}$$

* Testing Engineer and Welding Engineer, respectively, California Shipbuilding Corporation, Wilmington, Calif.

All cards are kept up daily by one clerk for all shifts and all students. From this card monthly averages are established to give the following figures for comparison of instructors, shifts and students, and also to gage improvement or make changes in the training process.

1. Average % operating efficiency:
   (*a*) by instructors.
   (*b*) by shift.
   (*c*) over all.
2. Average arc hours required to pass qualification tests.
3. Training time vs. arc hours vs. tests passed.

All students are compared daily with the standards set up as above. Any variations from the standards are analyzed and if below average, the student is checked by the superintendent and the instructor. The following possible check chart of variations and possible causes is then used to determine what is happening:

1. High operating efficiency, average training time, but repeated failure of weld tests.

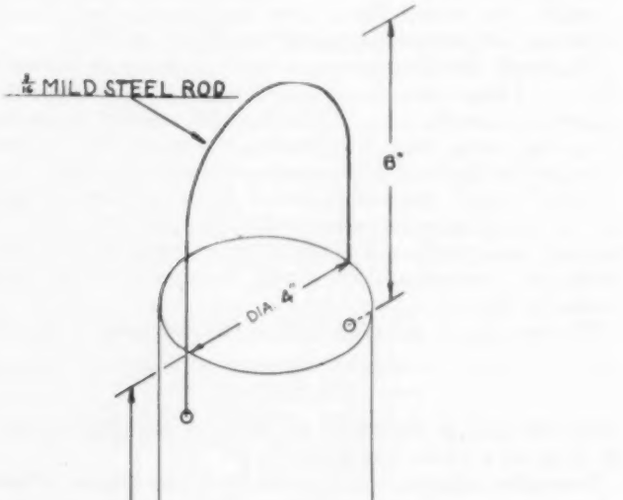


Fig. 1

Analysis:
1. Poor instruction.
2. Insufficient instruction.
3. Repetition of an error in manipulation which has not been corrected.

ROD CAN #_____ BADGE #_____ NAME:_____ SHIFT:___

DATE:	ISSUED RODS	RETURNED STUBS	ARC TIME	DATE:	ISSUED RODS	RETURNED STUBS	ARC TIME

Fig. 2

4. Nervous student.
5. Incompetent student.

2. Low operating efficiency and repeated failure of weld tests.
   Analysis:
   1. Student is lazy or low in intelligence.
   2. Physical handicap of student.
   3. Lazy or incompetent instructor.
3. Average operating efficiency, but repeated failure of weld tests.
   Analysis:
   1. Lazy or incompetent instructor.
   2. Nervous student.
   3. Insufficient training for specific student who requires more than average attention and time.
4. Low operating efficiency: other results good.
   Analysis:
   1. Student should work harder. Has ability.
   2. Instructor should keep student going uphill faster.
5. High operating efficiency: all results good.
   Analysis: More than satisfactory.

A complete analysis can thus be made to keep a close control on all students and instructors.

Results have been more than gratifying in the use of this system. During the first two months' operations, an over-all improvement in the effectiveness and attainment of training objectives is estimated at about 30%.

A research program is being pursued at the present time with a view to the determination of the following, using this control system:

1. Fatigue factors in training.
2. Over-all training pattern plotting the course of absorption of learning by students against arc hours and training time.
3. Ideal training time.
4. Process of training according to sequence of presentation of units of training.

Such data will be published when results are obtained and correlated for a reasonable period of time.

We wish to extend our appreciation to the following for their efforts and full cooperation in the use and application of this method of efficiency and production control of training personnel for manual arc welding:

Geo. H. Davies, Supt. Weld Training.
C. Hoffman, Asst. Supt. Weld Training.
C. Brandvold, Asst. Supt. Weld Training.
C. S. Kier, Supt. Electrode Distribution.

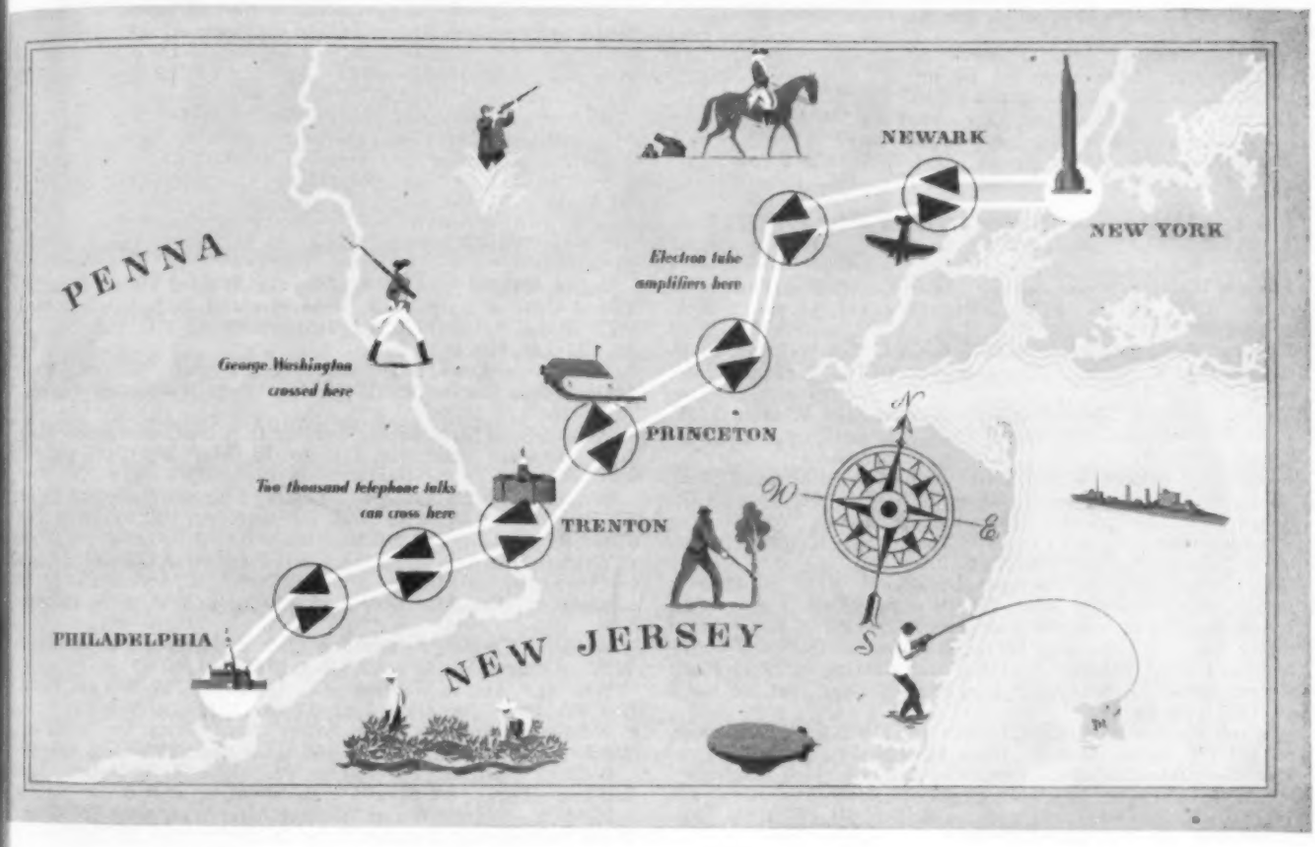
NAME:_____
BADGE #_____ STARTING DATE:_____
INSTRUCTOR:_____

ARC HOURS DATE	HRS.	DATE	HRS.	TRAINING TIME DATE	HRS.	DATE	HRS.	PER CENT EFFICIENCY DATE	%	DATE	%	TESTS & RESULTS DATE	RESULT	DATE	RESULT

Fig. 3

90-MILE LABORATORY

for Telephone and Television



BETWEEN telephone offices in New York and Philadelphia once stretched a strange sort of laboratory. Most of the way it was underground; engineers made their measurements sometimes in manholes. It was a lead-sheathed cable containing two "coaxials" – each of them a wire supported in the center of a flexible copper tube the size of a lead pencil.

Theory had convinced engineers of Bell Laboratories that a coaxial could carry many more telephone talks than a full-sized voice frequency telephone cable; that it could carry adequately a television program. Experimental lengths were tested; terminal apparatus was designed and tried out. Finally, a full-sized trial was made with a system designed for 480 conversations. It was successful; in one demonstration people talked over a 3800-mile circuit looped back and forth. Now the cable is carrying some of the wartime flood of telephone calls between these two big cities.

This cable made television history also: through it in 1940 were brought spot news pictures of a political convention in Philadelphia to be broadcast from New York. Bell System contributions to television, which began with transmission from Washington to New York in 1927, have been laid aside for war work. When peace returns, a notable expansion of coaxial circuits is planned for both telephone and television in our Bell System work.

BELL TELEPHONE LABORATORIES

Exploring and inventing, devising and perfecting for our Armed Forces at war and for continued improvements and economies in telephone service.

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(*Continued from page 548*)

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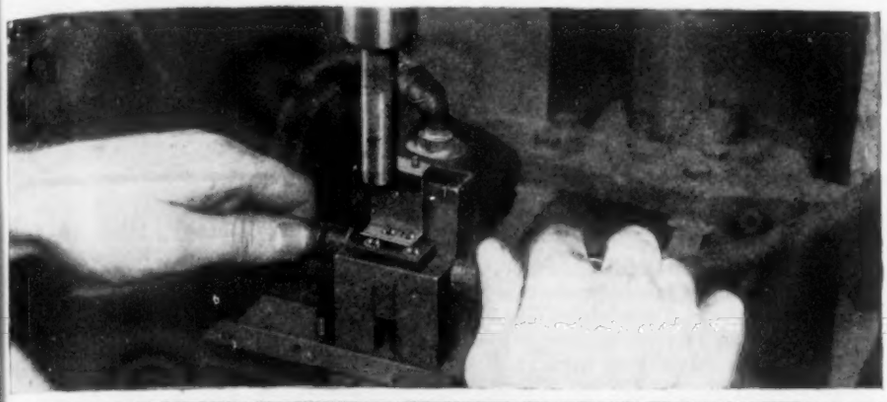
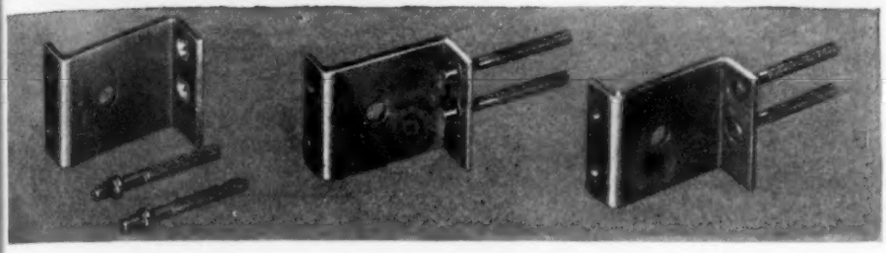
Electrical Upsetting *with* Mallory Electrodes





produces Three Hundred Assemblies an hour instead of sixty

FASTENING two bolts to a bracket, with no protruding bolt heads, is now done by electrical upsetting in two simple operations—using Mallory Resistance Welding Electrodes—at rates up to 300 assemblies an hour, as against 60 an hour by conventional methods.

Two threaded bolts are inserted in a lower die made of a Mallory alloy faced with Elkonite*. A bracket, punched with square, countersunk holes, is placed over the bolts and held in position by two locating pins. Upsetting is performed by the upper electrode, also made of a Mallory alloy with an Elkonite face. Heated metal flows into the bracket holes and joins the bolts securely, flush with the bracket's surface. Then the completed assembly is ejected with an air operated stripper.

Long production runs, with minimum down time for electrode dressing, are achieved with this set-up, because the Elkonite welding surfaces combine high mechanical hardness with suitable electrical and thermal conductivity.

Experienced Mallory engineers can help you to determine the techniques of resistance welding best suited to your production. They can aid you in selecting electrodes of the correct alloy—whether you need spot welding tips or holders, seam welding wheels, or dies for flash, butt or projection welding. Consult Mallory today. Write for a free copy of the illustrated catalog on Mallory electrodes.

*Reg. U.S. Pat. Off. for refractory metal compositions.

ATTENTION—WELDING ENGINEERS!

Now available—Third Edition Mallory Resistance Welding Data Book, a comprehensive text on resistance welding practices. Sent gratis to resistance welding engineers, when requested on company letterhead. Available to students, libraries and schools at $2.50 per copy, postage paid.

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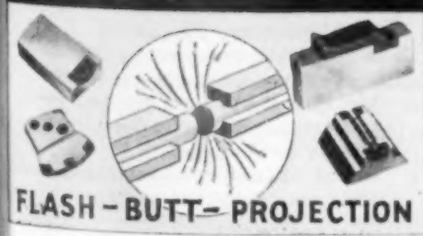
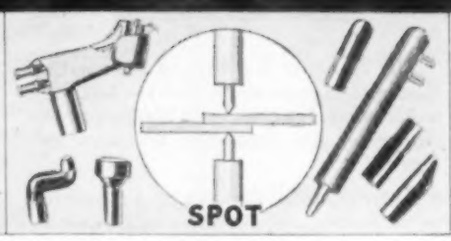
MALLORY *Standard Resistance Welding Electrodes*





THE AMERICAN WELDING SOCIETY

ACTIVITIES – RELATED EVENTS

OBITUARY

Edmund A. Doyle

Edmund A. Doyle, Consulting Engineer for The Linde Air Products Co., a Unit of Union Carbide and Carbon Corp., and a former President of the AMERICAN WELDING SOCIETY, died suddenly at his home, Friday evening, May 4th. He was 64 years old.

Edmund A. Doyle

Mr. Doyle was born in Baltimore, Md., on Jan. 13, 1881. He received his early education at Baltimore and was graduated from Johns Hopkins University as a Mechanical Engineer. During the first World War, Mr. Doyle served in the United States Army, Corps of Engineers, starting with the rank of first lieutenant and rising to the rank of Major.

Mr. Doyle began his association with The Linde Air Products Co. in 1922 as Assistant General Sales Manager in Charge of Service. Four years later he became Consulting Engineer on Process Development, a position he held until his death. One of his early contacts with the field of welding and cutting was in connection with the cutting activities incident to raising the battleship *Maine* from Havana Harbor in 1908.

Mr. Doyle served as a director of the AMERICAN WELDING SOCIETY and was President of the organization in 1930–31. He was responsible for the organization of the Committee on Building Codes and was chairman of this committee until his election as president of the SOCIETY.

Mr. Doyle was a 32nd Degree Mason, a charter member of the Society of American Military Engineers and a member of the National Democratic Club.

Hans Nielsen Boetcher

Hans Nielsen Boetcher, Assistant to Superintendent of Power Production Stations Department, Consolidated Gas Electric Light and Power Company of Baltimore, died in that city on April 19, 1945, after a short illness. He was 47 years of age.

A native of Hamburg, Germany, Mr. Boetcher received his formal education at the Technical University in Hannover. Prior to his coming to this country in 1924, he was with the Siemans Electric Works, Hamburg. Continuing in the field of engineering associated with the generation of electric power, he entered the employ of the Consolidated Gas Electric Light and Power Company in 1925. Engaged primarily with the design, construction and operation of steam electric generating plants, Mr. Boetcher was prominent in recent years in metallurgy as applied to the Power Industry. He was known as an authority on corrosion and failure of metals in power boilers and other power plant equipment, being the author of numerous papers and studies on these subjects.

His knowledge of metals was also applied to welding, in which he had great interest, and his contributions in this field were in large degree responsible for the rapid advance of this art. He was an Associate Member of the AMERICAN WELDING SOCIETY and was prominent in the organization of the Maryland Section, being local chairman at one time.

He was a member of The American Society of Mechanical Engineers, taking an active part in the committee work of that society. He served on numerous committees of the Edison Electric Institute, being a member of the Prime Movers Committee at the time of his death. He was also a committee member of the American Society for Testing Materials, being Chairman of the Subgroup on Graphitization of High Temperature Pipe.

Mr. Boetcher commanded the respect of all his associates, not only for his knowledge and engineering ability, but also for his kind appreciation and cheerful, hearty cooperation with all with whom he came in contact. His death is a great loss to the Power Industry and to the engineering profession.

1945–46 NOMINATIONS

The National and District Nominating Committees have announced the following nominations for National Officers and Directors of the AMERICAN WELDING SOCIETY.

These nominations have been submitted to the membership for letter ballot vote.

President—WENDELL F. HESS, Head of Welding Laboratory, Rensselaer Polytechnic Institute, Troy, N. Y.

1st Vice-President—HAROLD O. HILL, Asst. Chief Engineer, Fabricated Steel Construction, Bethlehem Steel Co., Bethlehem, Pa.

2nd Vice-President—G. N. SIEGER, Pres. & Gen. Mgr., S-M-S Corp., 1165 Harper Ave., Detroit, Mich.

Directors-at-large (to serve for 3 years)—
CHARLES H. JENNINGS, Section Engr., Welding Section, Westinghouse Electric Corp., E. Pittsburgh, Pa.
A. B. KINZEL, Chief Metallurgist, Union Carbide & Carbon Res. Labs., Inc., 30 E. 42nd St., New York, N. Y.
C. M. UNDERWOOD, Manager, Welding Dept., Northern Ordnance Co., Minneapolis, Minn.
R. D. THOMAS, President, Arcos Corp., 401 N. Broad St., Philadelphia, Pa.

District Vice-Presidents

No. 1 (New York and New England):
F. W. DAVIS, Metallurgist, E. B. Badger & Sons Co., Boston, Mass.

No. 2 (Mid-Eastern):
W. G. THEISINGER, Asst. to Vice-President, Lukens Steel Co., Coatesville, Pa.

No. 3 (Southern):
SYDNEY SWAN, Surveyor, American Bureau of Shipping, Pascagoula, Miss.

No. 4 (Central):
B. L. WISE, Asst. Mgr. Welder Div., Federal Machine & Welder Co., Warren, Ohio.

No. 5 (Mid-Western):
R. E. MCFARLAND, Engineer, Western Electric Co., Inc., Chicago, Ill.

No. 6 (Mid-Southern):
W. S. EVANS, Materials Engineer, Curtiss-Wright Corp., St. Louis, Mo.

No. 7 (Western):
C. P. SANDER, General Supt., Western Pipe & Steel Co. of Calif., Los Angeles, Calif.

ELECTRONICS REPRESENTATIVE

Frank B. Russell of Drexel Hill, Pa., has been appointed as the direct factory sales representative for the United Electronics Company, Newark, N. J. This was recently announced by Mr. C. A. Rice, vice-president in charge of sales.

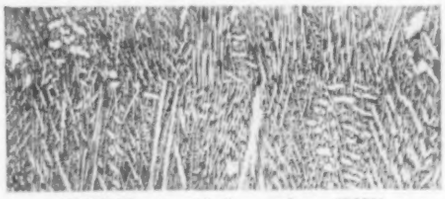
Mr. Russell will cover territory including Eastern Pennsylvania, Delaware, Maryland and Virginia.

United Electronics manufactures transmitting and industrial electronic power tubes.

Yes, you can SPOT WELD Monel, Nickel and Inconel

This 12-page bulletin gives data which were obtained under optimum laboratory conditions for spot welding Monel, Nickel and Inconel. These findings are proving useful in the establishment of shop standards when recognition is given to the experience noted below.

TYPICAL MONEL WELD
made in 0.062-in. annealed sheet (7.5X).



CENTER *of weld shown above (70X).*

NEW SHOP TEST SPEEDS MACHINE SET-UP

A quick method of sectioning welds has proved very satisfactory in connection with machine adjustment and weld evaluation. The method consists of scribing a line across the center of the weld, shearing or sawing adjacent to the center of the weld, smoothing this cut by filing or grinding to the center line, and then microetching the resulting section. Visual examination of the section shows diameter, penetration, structure and gross flaws. If the strength-diameter relation is known for a particular case, the approximate weld strength may easily be predicted from its dimensions. The time needed to perform this test is about two minutes. Concentrated nitric acid is a satisfactory etchant for Monel and Nickel; aqua regia for Inconel. This method appears to be of much greater value than the "peel test" as a method of setting up machines in the shop. The information obtained from the "quick section method" is a valuable supplement to the standard weld tests.

Before this bulletin was published, little information on spot welding of these metals was available. But here you have the results of *two years' research* sponsored by The International Nickel Company at the Welding Laboratory of Rensselaer Polytechnic Institute.

The research was carried out on several thicknesses of Monel, Nickel and Inconel sheet to determine optimum welding conditions, i.e., those producing the best welds consistent with high strength, soundness and low distortion.

The effects of pressure ... electrode size and shape ... time ... temper and grain size ... current ... the cause and control of porosity ... all were among the many factors studied.

The condensed table below typifies the valuable information that's been brought between the covers of this bulletin.

ANALYSIS OF RECOMMENDED CONDITIONS FOR SPOT WELDING ANNEALED MONEL

Metal Thickness Inches	Flat Electrode Diameter Inches	Total Electrode Pressure Pounds	Unit Electrode Pressure Psi	Firing Time Cycles	Current Amperes	Strength Per Spot Pounds	Spot Diameter Inches
0.021	1/8	184	15,000	12	6,200	570	0.137
0.032	3/16	690	25,000	12	10,600	1,290	0.212
0.062	5/16	2,685	35,000	12	20,700	3,930	0.320
	1/4	1,962	40,000	12	15,300	3,215	0.280
0.093	3/8	2,765	25,000	20	22,600	6,300	0.408
	5/16	2,685	35,000	12	20,000	4,370	0.320
0.125	1/2	4,910	25,000	30	30,800	10,950	0.539
	3/8	3,870	35,000	30	21,300	7,800	0.441
	3/8	4,420	40,000	20	23,900	6,825	0.393

NOTE: The values shown for "Strength Per Spot, Pound" were obtained under optimum laboratory conditions. They should not be used as shop standards. Experience has indicated that 80% of the strength values shown can be used as a minimum average shear strength per spot for application to shop standards.

If you're using (or planning to use) Monel, Nickel or Inconel, you'll want a copy of this free bulletin. It's a full discussion of all the factors involved in their spot welding.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

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67 Wall Street, New York 5, N. Y.

Gentlemen: Please send me a copy of your bulletin, "The Spot Welding of Nickel, Monel and Inconel."

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CORRECTION NOTICE

In the alphabetical list of members published in the Year Book, the following name was inadvertently omitted.

Lawrence, Harold E. (C), President, Welding Fabricating Co., 39 Summit St., Newark 4, N. J.

FIRST ALL-WELDED HOSPITAL

Preliminary details on what is believed to be the first all-welded hospital building in the country have been received by officials of The Lincoln Electric Co., Cleveland, Ohio.

The 18-story hospital, shown in the accompanying sketch, embodies the most progressive ideas in modern structural design and furnishes a significant clue to the general type of building construction we can expect as soon as restrictions on material are lifted.

It is proposed that the framework of the new unit, to be known as Kahler Hospital, will be designed as a continuous structure of beams and their connecting members, welding details of which are based on past analysis and conform to general engineering acceptance.

In preparing the specifications, the architects, Ellerbe and Company, St. Paul, Minn., discarded all concepts of riveted construction which tends to restrict the range of application of certain welding details.

Architect's Sketch of Proposed New Kahler General Hospital at Rochester, Minn., Which Will Be of All-Welded Construction

The hospital building, which will cover an area of 150 x 270 ft., or about half a city block, will be built of welded steel with concrete floor slabs and is to be erected at Rochester, Minn.

FORGING AHEAD IN THE WELDING BUSINESS

The above is the title of a mimeographed pamphlet with paper covers, written and published by Robert S. Hale, 57 Post St., San Francisco 4, Calif. The pamphlet consists of 56 pages of helpful suggestions on the business (not technical) side of starting a Job Welding Shop. Price per pamphlet $7.50.

WELDED GEAR BLANK

(Correction Notice)

On page 386 of the April 1945 issue of THE WELDING JOURNAL, there appeared a photograph and description under the above title. However, the name of the company was inadvertently left out. It is the Farrel-Birmingham Co., Inc., Ansonia, Conn.

McMASTER JOINS BATTELLE

Dr. Robert C. McMaster, formerly associated with the electrical engineering staff at the California Institute of Technology, has been appointed to the staff of Battelle Institute, Columbus, Ohio, and assigned to its division of industrial physics.

A specialist in high-voltage electrical engineering, Dr. McMaster holds Bachelor of Science, Master of Science and Doctor of Philosophy degrees from the California Institute of Technology. He is a member of the American Institute of Electrical Engineers, serving on its Electric Welding Commmittee; the AMERICAN WELDING SOCIETY, serving on its Resistance and Flash Welding Committees; the Industrial Radium and X-Ray Society; Sigma XI, honorary scientific society; Tau Beta Pi and Theta Tau, honorary engineering societies; and Eta Kappa Nu, honorary electrical engineering society.

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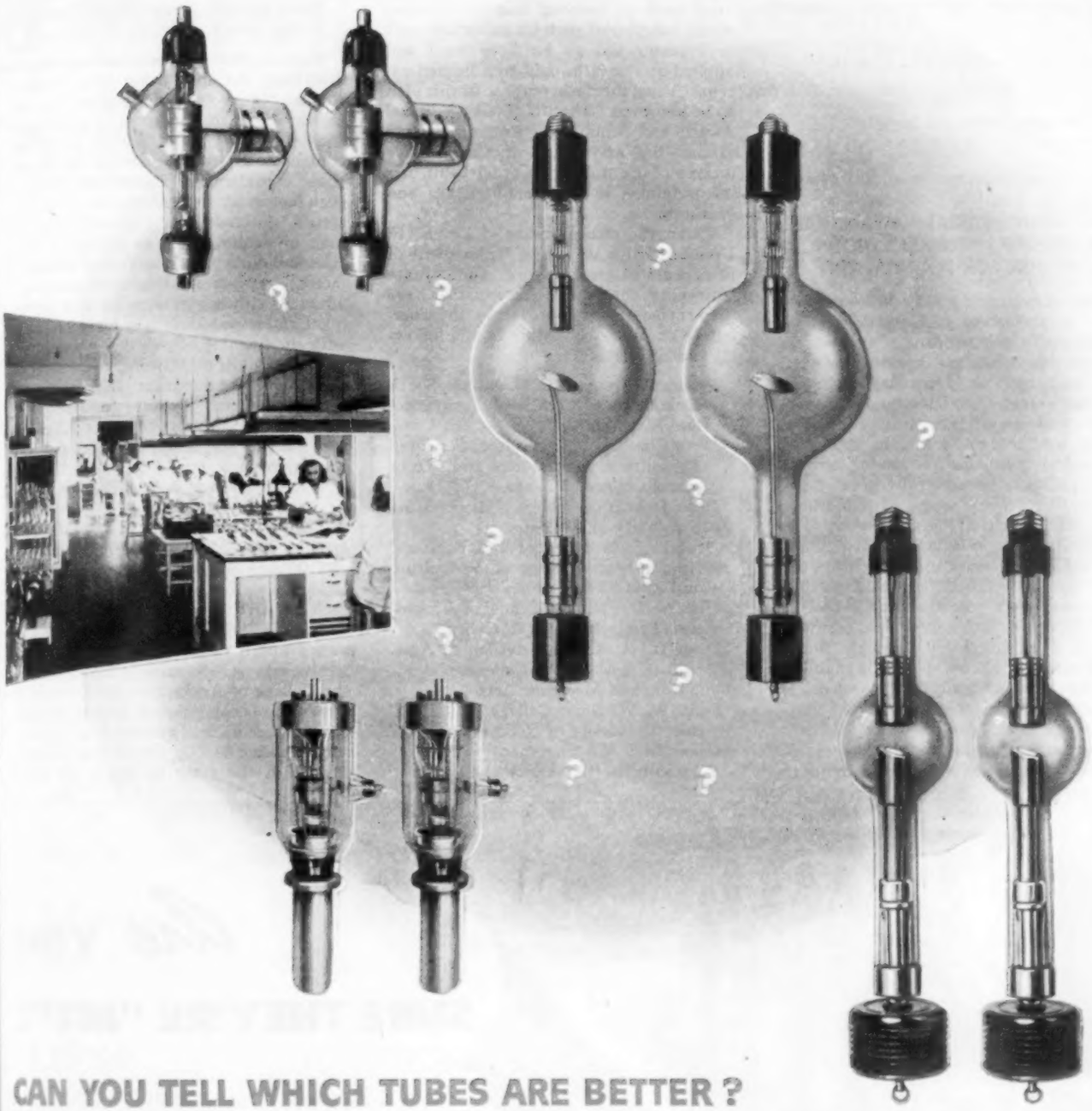
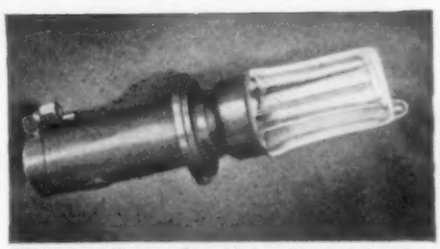
Westinghouse Elec. & Mfg. Co. . . . Inside back cover



CAN YOU TELL WHICH TUBES ARE BETTER?

Two tubes of the same type may look exactly alike, but if one was assembled in the Machlett "White Room" while the other was put together under average factory conditions, there would be a considerable difference between them. In lighting, cleanliness and conditioned environment, the "White Room" resembles a hospital operating room, and tubes passing through it remain free of internal contamination that would lessen their stability, shorten their life. Such tubes will give full-rated, predictable performance, and prove uniformly economical and satisfactory. It was to achieve such improved results that Machlett built the first "White Room" in the industry — subsequently adopted by others. Many still newer Machlett techniques, such as this, continue to improve the quality and performance of our products. In this way, Machlett leadership in the electron tube field is maintained.

When you need a medical or industrial X-ray tube, or an oscillator, amplifier, or rectifier for radio or industrial purposes, select a Machlett. It will pay you in stability of operation and long life. For information as to available tubes, write Machlett Laboratories, Inc., Springdale, Connecticut.



EG-50—an X-ray tube with beryllium window for radiography of light materials and thin sections.

MACHLETT

X-RAY TUBES SINCE 1897

TODAY THEIR LARGEST MAKER

STOCKHOLDERS VOTE NAME CHANGE

Stockholders of the Westinghouse Electric and Manufacturing Co. at their recent annual meeting voted to change the Company's name to Westinghouse Electric Corp., for simplicity and brevity.

NEW AGRICULTURAL AWARD AND SCHOLARSHIP PROGRAM ANNOUNCED BY LINCOLN FOUNDATION

Announcement of a $37,500 Award Program to encourage investigation, study and scientific development of arc welding in farm operation and maintenance has been made by The James F. Lincoln Arc Welding Foundation, Cleveland, Ohio.

The first Award Program of its kind offered by the Foundation in this field, the project is intended to enable agricultural producers to more fully develop the arc welding process along scientific lines and to widen its utility to the farmer. The development of procedures and methods will enable the farmer to benefit from the advantages of welding. It is believed that more complete application of the process will help the industry overcome many of the obstacles presented through shortages in material and manpower by enabling operators to conserve their mechanical equipment and machinery to build various structures and devices which add convenience and efficiency to farm operation.

Nowhere is the need for efficiency more vital than in farming and this process which has played such an important part in industry has so far been used and applied on the farm only to a limited extent. Thus, the basic purpose of this plan to be known as "The $37,500 Agricultural Award and Scholarship Program," is to extend the knowledge of the modern process of arc welding in order to further its usefulness in farm maintenance and operation.

Under the chairmanship of Dr. E. E. Dreese, Chairman of the Department of Electrical Engineering of Ohio State University, the rules of participation have been reviewed and approved by the Committee on Rules consisting of the following educators in agriculture:

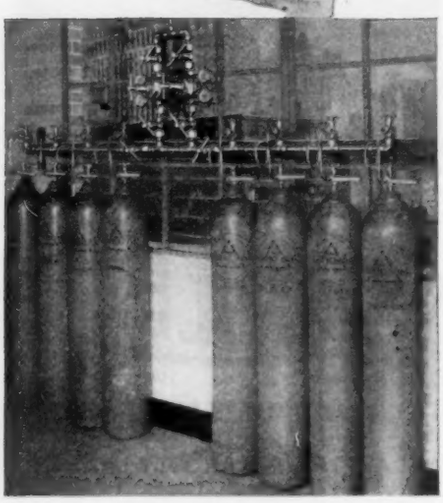
President Lyman E. Jackson, South Dakota State College of Agriculture and Mechanic Arts
Dean Charles N. Shepardson, School of Agriculture, Agricultural and Mechanical College of Texas
Dean J. A. Hill, College of Agriculture, University of Wyoming
Dean L. E. Call, School of Agriculture, Kansas State College of Agriculture and Applied Science
Dean S. W. Fletcher, School of Agriculture, Pennsylvania State College
Dean H. H. Kildee, Division of Agriculture, Iowa State College of Agriculture and Mechanic Arts
Dean W. W. Burr, College of Agriculture, University of Nebraska
Dean Paul W. Chapman, College of Agriculture, University of Georgia
Dean John F. Cunningham, College of Agriculture, Ohio State University

The awards will be made for papers describing the application of arc welding to maintenance of farm equipment, machinery or farm structures, including the construction of miscellaneous parts and contrivances. In the treatment of this topic consideration should be given to such factors as: procedures, methods, materials, electrodes, etc., as well as economies of welding, such as savings in both time and money, or in any other pertinent factor; type of welding equipment best adapted with suggestions for new equipment and accessories; any factors dealing with the learning of welding.

There are 131 cash awards in each of two divisions. The Program offers a total of $30,000 in cash awards, and $7500 in scholarships for the Colleges of Agriculture in the states in which the award winners reside.

The cash awards in each division are as follows: a first award of $3000, second of $2000, third of $1000, fourth of $750, fifth of $500, sixth of $250, twenty-five of $100 each and one hundred of $50 each.

There are 15 scholarship awards of $250 each in each division. The College of Agriculture in the state in which the first award winner of each division resides will receive six scholarships totaling $1500; the College of Agriculture in the state in which the second award winner of each division resides will receive four scholarships totaling $1000; the College of Agriculture in the state in which the third



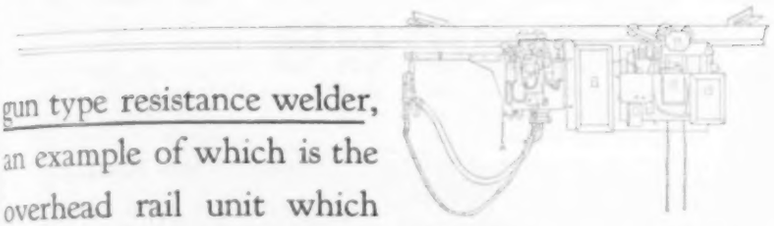
Are YOU
SURE THEY'RE "MT"?

● The odds are against your cylinders being "MT" if you don't have a modern manifold installed in your shop or plant.

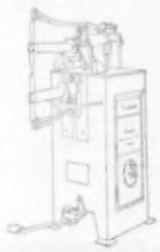
Learn *now* how a RegO Manifold, designed to your exact requirements, can cut your gas costs by withdrawing *all* the gas from *all* the cylinders . . . there's no obligation . . . simply write.

REGO ARMY E NAVY
The BASTIAN-BLESSING Company
4241 Peterson Ave. • Chicago 30, Ill.
Pioneers and Leaders in Equipment for Using and Controlling High Pressure Gases

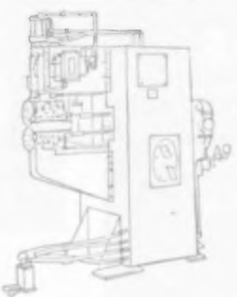
to Metal, Costs . . .



gun type resistance welder, an example of which is the overhead rail unit which can be rolled up and down an assembly line and allows operator a wide radius of travel about the work (see above) . . . Spot welders, from small utility rocker arm types (see left) to heavy duty units capable of welding sheets up to 3/8 inch each have wide use in the metal working industry . . . Roll spot and seam welders have equally broad application, produce a continuous or intermittent weld, automatically indexed . . . and many other cost saving types.



Federal wants to make available to you full information on applications of resistance welding to better and faster fabrication. We want to bring you up to date on resistance welding as a tool for modern production. Federal is ready to help if you will tell us WHAT YOU WANT TO KNOW ABOUT RESISTANCE WELDING.



Consult "the name of authority on resistance welding".

Federal

WELDER CO. 206 Dana Street WARREN, OHIO

VERSATILE MODERN PRODUCTION TOOLS

BARREL WELDERS

Of the millions of welded steel drums or barrels used to distribute gasoline and oil to our mechanized war in far corners of the earth, a vast majority are welded on Federal Barrel Welders. Not only has a major percentage of the industry for many years been equipped with Federals, but The Federal Machine and Welder Company designed and built several complete barrel manufacturing plants set up by the army at distant bases to augment the tremendously increased output of the home industry.

Seam welds (resistance welded) in such containers must be able to take terrific punishment. Immediately after welding, the barrel shells pass through a machine which forms two rolling rings in the side, by stretching the steel outwardly under great pressure. Then, too, the loaded barrels, weighing over four hundred pounds, often are dropped a distance that subjects them to thousands of pounds impact. The weld must hold.

NEW FOLDERS

Most recent informative bulletins on Federal Resistance Welders to come from the press are the new "Type R" bulletin describing a complete line of rocker arm utility spot welders . . . and "Type P" Bulletin with details of Federal's Press Welders, used for projection welding, mash welding, etc. Bulletins are available now on request.

HOUSEWARE PRODUCTION

Anticipated expansion of houseware production points up the advantages of Federal resistance welding for the fast, low cost application of handles to enameling steel or aluminum pots and pans. Press type welders are used, with dies that permit rapid loading, give production of 500 to 800 handles per hour, depending upon type of handle applied. Cost with one manufacturer is one-fifth previous methods.

INTERESTING PLANT

Full details of a complete manufacturing plant for high production of large resistance welded tank turret rings (up to seven feet OD) are in a book just released by The Federal Machine and Welder Company. The company designed and built the entire plant, shipped to a foreign power. Point of interest is that similar rings, which can be made with same equipment, could be used for large ring gear blanks, rotating table bearings, possibly locomotive tires. Limited number available to executives, technical men, sufficiently interested to write to Federal giving name, official title and company name.

award winner of each division resides will receive two scholarships totaling $500; the College of Agriculture in the state in which the fourth award winner of each division resides will receive two scholarships totaling $500. The College of Agriculture in the state in which the fifth award winner of each division resides will receive one scholarship of $250.

The selection of the recipients of scholarships, who are to be students in Agricultural Engineering or in allied scientific agricultural fields will be made by a committee of three in each college which shall include: the Dean of the College of Agriculture; the head of the Department of Agricultural Engineering (wherever such a department exists), and a third member to be selected by these two. In case there is no Department of Agricultural Engineering, the Dean will select two persons to act with himself as a committee.

The scholarship funds may be used for one or more students for one or more years, depending upon the number of scholarships available in the particular scholarship fund. This shall be decided by the committee designated in the preceding paragraph.

The only requirements of the donor with regard to the recipients of scholarships is that the scholarships are to be awarded on the basis of scholastic attainment, imagination and promise without regard to the financial need of the students.

The winners of all awards will be further honored since the scholarships in their respective states will be given names: "The John Doe (using name of award winner) Scholarship of the Lincoln Foundation."

Those who may participate in the Program are divided into two divisions: Division 1—Persons actively engaged as agricultural producers of food and fiber products, or in the raising and breeding of farm animals, and Division II—Persons engaged professionally in agricultural education or services, including teachers of agriculture, county agricultural agents, soil conservationists and graduate students in Agricultural Engineering.

The Jury of Award for judging the papers will be drawn from appropriate fields of agriculture and engineering. Selection of the jurors will be under the Chairman of The Jury of Award, Dr. E. E. Dreese, Chairman of the Board of Trustees of The Lincoln Foundation.

Further details of "The $37,500 Agricultural Award and Scholarship Program" which closes June 15, 1946, may be obtained by writing the Secretary, The James F. Lincoln Arc Welding Foundation, Cleveland 1, Ohio.

The James F. Lincoln Arc Welding Foundation has conducted numerous award programs in the past. Among these have been the General Industrial Award Program and the Industrial Progress Award Program, which have been participated in by business executives, engineers and industrial workers.

Another recent program of The Foundation was the Undergraduate Award and Scholarship Program, participated in by engineering undergraduate students. A series of awards for textbooks to be used in technical schools and universities covering Modern Machine Design and Modern Structural Design was announced by The Foundation, April 2nd.

The Foundation has also been active in establishing special book collections in engineering schools.

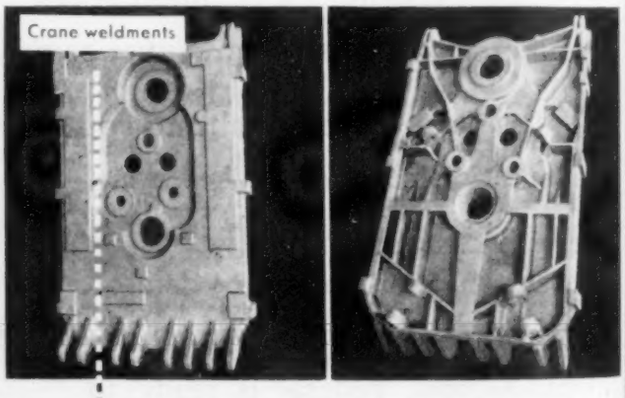
The Foundation, which was created in 1936 in honor of James F. Lincoln, President of The Lincoln Electric Company, Cleveland, Ohio, has also published books such as *Arc Welding in Design*, *Manufacture and Construction*, *Studies in Arc Welding* and *Maintenance Arc Welding*.

HARD FACING BOOKLET

To be successful, Hard Facing should have a high Rockwell or Brinell hardness and retain its hardness and resistance to abrasion at high red heat. It should have enough toughness to withstand impact, and enough adhesion to form an unbreakable bond with the parent metal, with slight penetration.

One of the requisites of a successful Hard Facing job is the proper technique of application which is quite different from that of welding steel to steel. A booklet published by Mir-O-Col Alloy Co., 2416 East 53d St., Los Angeles 11, Calif., is an effort to set forth simply and understandably the result of twenty years of research and successful application of Hard Facing. Available free on request.

For Better and Easier Welding
DUCTONE AC
(E6011 and E6013)
WELDING RODS
Prompt delivery can be made on DUCTONE AC rods, the electrode that has been designed especially for AC welding. This is a premium quality electrode that is far superior to all other AC rods. It is noted for its extra-stabilization in the coating, which makes striking and maintaining an arc easy, and for its all position use . . . Small sizes are especially good for thin sheet metal. Excellent for vertical and overhead welding on DC positive polarity. Extruded all sizes from 1/16" to 1/4" See your dealer.
Territories Available for Distributors
Reach for DUCTONE AC Welding Rods
Chicago Steel and Wire Co.
103rd St. and Torrence Ave.
Chicago 17, Illinois



WONDERS NEVER CEASE!

That's a fact . . . in a modern fabricating plant. Take the crane weldments shown above . . . 5100 lbs. of complicated subassemblies . . . each a fair engineering and welding project in itself.

Work of this character features operations at United, where 32 years of experience and the latest in equipment are joined to produce welded products and parts with precision, speed and economy.

Submit your drawings. Consult our Engineers.

THE UNITED WELDING CO.
MIDDLETOWN, OHIO
WELDING FABRICATORS OF MODERN DESIGN
SINCE 1913

AO CLOTHING FOR HOT WEATHER WELDING

AO Short Jacket No. 203CL: Full protection for arms, neck, chest and shoulders.

AO Cape Sleeve and Bib No. 208B-CL: Complete protection for shoulders, arms and front of body. Detachable bib.

AO Sleeves No. 209CL: Excellent protection for arms only.

Here are comfortable garments for warm weather bench welding, cutting and burning. Made from high grade chrome tanned leather, these garments provide ample protection for those parts of the body which are exposed. Yet, they eliminate the necessity of wearing hot, heavy clothing over parts of the body which are not in danger from sparks or molten metal.

AO carries a complete line of welders' clothing — jackets, pants, overalls, spats, leggings and gloves. Send to your nearest AO Branch Office or direct to the company for complete information.

ARMY E NAVY

American Optical

COMPANY

SOUTHBRIDGE, MASSACHUSETTS

VICE-PRESIDENTS OF THE BABCOCK & WILCOX CO.

Auguste G. Pratt, President of The Babcock & Wilcox Co., announced recently that the Board of Directors had elected two additional Vice-Presidents, Alfred Iddles and J. H. King. Mr. King has been Manager of the Marine Department of the Company since 1932, and Mr. Iddles, special assistant to the Vice-President in charge of engineering.

Mr. Pratt was re-elected President, and Isaac Harter, E. G. Bailey and C. W. Middleton re-elected as Vice-Presidents. A. E. Phin was re-elected Comptroller, and William Sheldrick, Treasurer and Assistant Secretary. C. U. Savoye has been appointed as an additional Executive Assistant.

BUDD PLANS TO RESUME BUILDING COMPLETE RANGE OF PASSENGER EQUIPMENT

The Edward G. Budd Manufacturing Company will resume the manufacture of modern, lightweight stainless steel railway passenger cars just as soon as manpower and materials are available, Edward G. Budd, President, announced in Philadelphia recently. The announcement said the Company, which eleven years ago pioneered the building of modern streamlined trains of stainless steel, would include among its postwar products railway passenger cars for both day and night occupancy as well as all types of recreational facilities required for the well-balanced, all-purpose train.

The program includes resumption of the now famous reserved seat sleeper coaches, or chair cars, developed by Budd during the '30s, as well as dining, lounge, tavern, observation, and several types of sleeping cars, Mr. Budd said.

QUINZIO JOINS CARBORUNDUM

JOHN R. QUINZIO, formerly with the Buffalo Foundry & Machine Co., is now connected with the Carborundum Co. of Niagara Falls, as Maintenance Engineer.

G.I.'S OPPORTUNITY

A guide book for those who would own their own business . . . not just a job, but a chance for true achievement . . . 34 authentic case histories of 34 successful concerns . . . the men, the ideas, the methods . . . that made them great.

The true stories that make up the contents of this booklet have been carefully selected from past issues of *Adventures in Business*. These particular stories have been reprinted because each of them is a sturdy guide-post for the man or woman who wants more than a job—who is ambitious to have his or her own business and a chance for true achievement in the postwar world.

Published by Ghost Town Press, 112 West Ninth St., Los Angeles 15, Calif. Price, 25¢ a copy.

ARCALOY DISTRIBUTOR

The Johnson Welding Company of 2640 West Van Buren St., Chicago, has been appointed the distributor for Arcaloy stainless and tool steel electrodes in the Chicago area.

This company is maintaining a complete stock of electrodes for immediate delivery and has a well-balanced personnel that will assure Chicago consumers prompt, efficient service on all their requirements for Arcaloy electrodes.

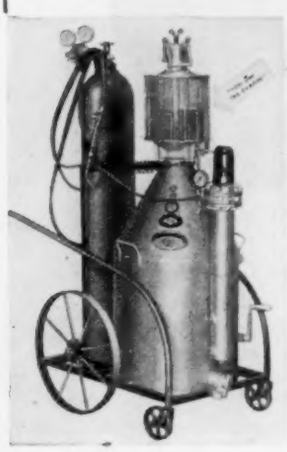
CLEANING AND SOLDERING CIRCULAR

An eight-page folder covering cleaning, derusting, phosphotizing, soldering and maintenance processes has been released by Klem Chemical Works, Industrial Chemicals, 1500–18 E. Woodbridge, Detroit 7, Mich.

A step-by-step procedure is outlined to acquaint the purchasing personnel with the diversified uses of the products which they are purchasing. Also this folder is written for the shop superintendent, the factory manager, the chemist and the metallurgist or the process engineer.

Fully described processes explain the use of phosphoric acid cleaners, alkali

ACETYLENE
Sight Feed
GENERATORS

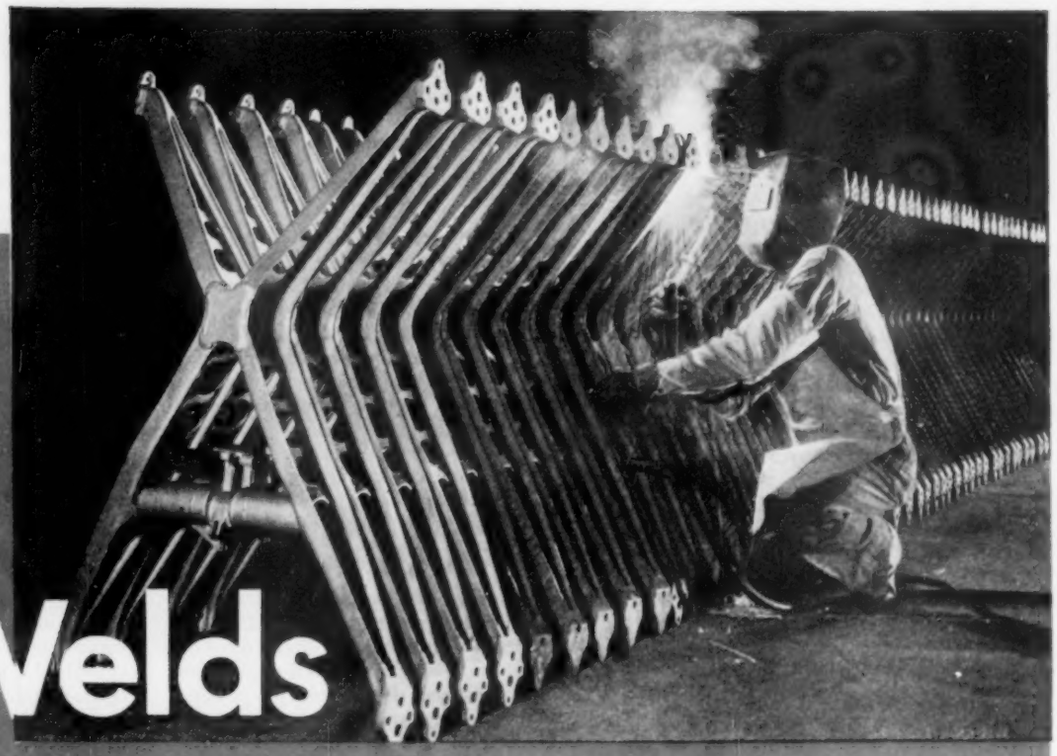


● The next time you light your acetylene torch, take a look at that flame. If you're still using "bottled" acetylene, you're burning DOLLARS—you know: those bits of green paper which seem so plentiful these days, but which never come so fast but that you could always use a few more.

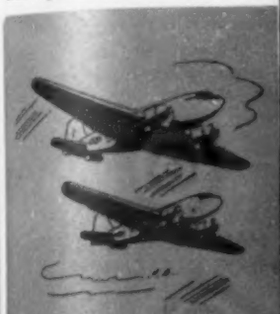
If you'd just make your own acetylene with a SIGHT FEED portable generator, you could put about two-thirds of each of those acetylene dollars in your cash register where they belong. You'd have an unlimited supply of top-quality gas for your welding and cutting; and don't forget: it's PORTABLE!

If you'd like to have more information, contact your jobber or

THE SIGHT FEED GENERATOR COMPANY
RICHMOND, INDIANA



SMITHWAY Electrodes in action—Welding press-formed alloy steel truss members at 13 points assured adequate strength, boosted production and saved materials and finished weight on C-47 landing gear trusses, as compared with former forged steel construction.



13 Welds -BROKE A BOTTLENECK

SAVING 56% in material . . . 34% in weight!

WHEN the U. S. Army's vital C-47 cargo plane was ready for mass production, there just wasn't enough drop forge capacity available in the nation to make the landing gear trusses pictured above.

So the part was redesigned for welding with SMITHway electrodes, and the bottleneck disappeared.

In this vital war emergency, welding as a production tool had replaced forgings with stampings, had avoided extensive machining time, had saved 106 pounds per unit of critical alloys, and assured unlimited production speed.

SMITHway Certified Welding Electrodes are vital factors in this and many other modern welding achievements. Now available for your use, too! They are helping win recognition for *welding* as a great production tool . . . as the best method for fabricating most products of steel. Write for catalog . . . and make the most of WELDING!

Buy an Extra War Bond This Month!

Mild Steel . . . High Tensile . . . and Stainless Steel

WELDING ELECTRODES

made by welders . . . for welders

SMITHway Welding Monitor trains better welders, faster.

SMITHway A. C. Welding Machine saves power; eliminates arc blow.

SMITHway Certified WELDING ELECTRODES

A. O. SMITH Corporation

NEW YORK 17 • PITTSBURGH 19 • CHICAGO 4 • TULSA 3
HOUSTON 2 • DALLAS 1 • LOS ANGELES 14 • SEATTLE 1
International Division: MILWAUKEE 1 • In Canada: JOHN INGLIS CO., LIMITED

power wash and still tank cleaners, maintenance cleaners, soldering fluxes, spray booth compounds and enamel or paint removers.

CANCELLATION OF A.S.T.M. MEETING AND EXHIBIT

The A.S.T.M. Executive Committee at its meeting on April 10th decided to cancel the 5-day regular Annual Meeting of the Society (scheduled for Buffalo, June 18–22, incl.) and instead to plan for a business session or sessions to be held probably the last week in June in New York City. This will permit actions on the formal standards to be consummated and Society business to be conducted. Also cancelled is the Exhibit of Testing Apparatus and Related Equipment which had been scheduled for the Annual Meeting. These actions were taken in full cognizance of the transportation situation and after consultation with officials of the Washington Committee on Conventions and the O.D.T.

The Society will proceed with the printing of its technical papers and reports that would normally have been presented and these will be distributed to the members as is customary. The Society's technical committees are holding meetings at various times and places and its work on specifications and tests for materials continues intensively.

SUPPORTING COMPANIES

Avery & Saul Co., South Boston, Mass. Engineers, designers and fabricators of all types of welded steel assemblies. Specialize in the welding of magnesium and aluminum alloys.

* * *

La Salle Electric and Mill Supply Co., 1360 Franklin St., Detroit 7, Mich., has been appointed by the A. O. Smith Corp. of Milwaukee, Wis., to provide complete and immediate service on their line of welding electrodes and a.-c. welding machines. Each type of welder, as well as large stocks of each rod, are maintained in Detroit. Each desk man and salesman has been a welder, or has taken training in the engineering and application of welding problems, thus providing a combination of experience and technical service.

* * *

Welding Equipment & Supply Co., 223 Leib St., Detroit, Mich., distributors of welding supplies and manufacturers of Eureka tool and die welding electrodes.

In the past ten years this Company has specialized in tool and die welding and pioneered the development of a complete line of tool and die welding electrodes, which are distributed nationally through distributor organizations. They maintain a staff of field engineers as specialists in tool and die welding

SETTING UP A WELDING UNIT

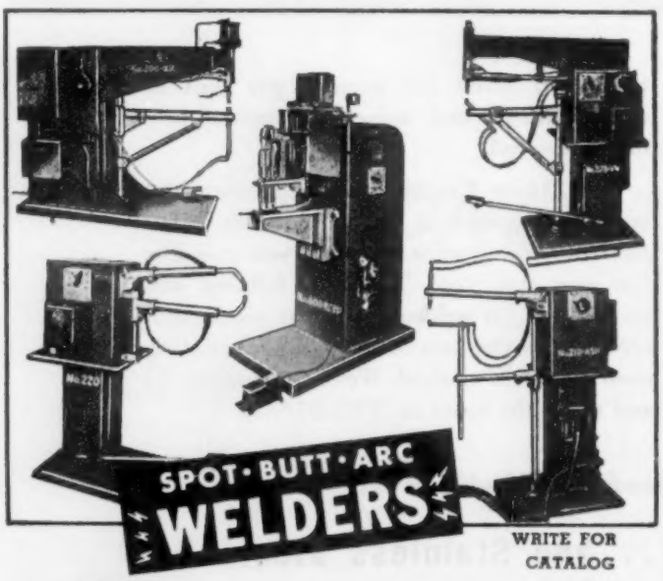
Victor Equipment Co. had made available for vocational training schools and to beginners, a 46-page, fully illustrated bulletin describing in simple and understandable language how to assemble a welding or cutting outfit entitled—"Setting Up a Victor Welding or Cutting Unit."

Anyone interested may secure a copy, free of charge or obligation, by requesting Form No. 1 from Victor Equipment Co., 844 Folsom St., San Francisco 7, Calif.

BRITISH MARINE SALVAGE AND HARBOR CLEARANCE

"Britain will have, on the termination of hostilities, the finest and largest fleet of salvage ships and craft available anywhere, a great amount of special equipment and a surplus of skilled and experienced salvage personnel," declared Captain J. B. Polland, Chief Technical Officer of the Salvage Department of the British Admiralty, in a recent lecture to the Royal United Service Institution.

A new electric oxyarc cutting torch, an electric arc process for under-water welding and the Cox submerged bolt driving gun are some of wartime contributions to salvage equipment.



WRITE FOR CATALOG

We manufacture a complete line of resistance spot welders from 1/4 to 300 KVA for all types of welding. There is an EISLER WELDER for every purpose.

TRANSFORMERS OF ALL TYPES

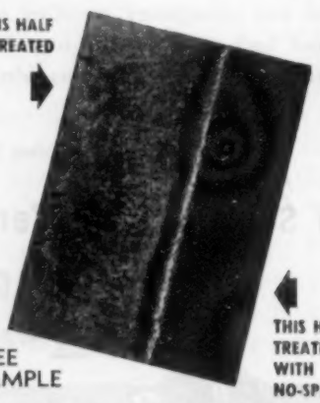
WE INVITE CONTRACT SPOT WELDING IN LARGE OR SMALL QUANTITIES.

CHAS. EISLER
EISLER ENGINEERING CO.
779-SO. 13th ST. Near AVON AVE NEWARK, 3 N. J.

for

BETTER WELDING
at
LOWER COST

THIS HALF UNTREATED



NO-SPAT

The Welding Fluid That Is Non-Toxic

THIS HALF TREATED WITH NO-SPAT

FREE SAMPLE

NO-SPAT prevents welding spatter from adhering to metal surfaces — protects metal against rust — saves time and labor costs. Especially valuable in keeping welding jigs clean. Unbiased scientific tests show NO-SPAT maintains maximum welding strength — reduces fumes 30 percent — does not produce carbon monoxide. Extremely inexpensive. No mixing required. No time wasted. Apply and start welding at once. Write for FREE SAMPLE and detailed engineering test Bulletin.

THE MIDLAND PAINT & VARNISH CO.
9126 Reno Avenue Cleveland 5, Ohio

Announcing

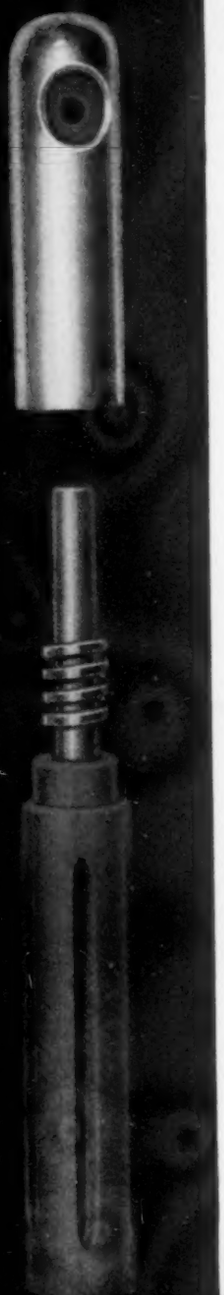
THE G-E ARMOR-CLAD

ELECTRODE HOLDER

(Cat. No. 279X17)

Featuring Operator Safety

- ★ COMPLETELY INSULATED
- ★ PROTECTED INSULATION
- ★ THREADS CARRY NO CURRENT
- ★ COOL AND COMFORTABLE



ELECTRODE SLOT
holds electrode firmly at proper angle

ALUMINUM SHEATH
protects insulation and resists weld spatter

PUSH-UP ROD
A slight twist of the hand tightens electrode, gives a firm "cushion grip." Threads do not carry current

HANDLE
is light in weight and comfortable to the grip. A twist of the handle releases electrode

SOLDERED CABLE CONNECTION
assures good electrical contact, resulting in a cool handle

HERE is an electrode holder *designed from the operator's point of view.* It is light in weight, amazingly cool in operation, and provides a new degree of safety. The head of the holder is completely enclosed in a sheath of aluminum armor to protect the insulation and to eliminate danger of accidental contact with the welding circuit. Spatter won't stick to this aluminum sheath—the holder stays clean, lasts longer.

Weighing only 15 ounces, this holder is compact, easy to use—and so precisely balanced that operator fatigue is materially reduced. Electrodes can be changed by a slight turn of the handle—and they can be melted down to a short stub end without gumming the holder with spatter.

Even with all of these safety and operating advantages, the new G-E Armor-Clad holder costs no more than conventional types. Order one today and let your own tests prove its safety and operating efficiency. Simply contact your G-E arc-welding distributor, or write to General Electric Company, Schenectady 5, N. Y.

Buy all the BONDS you can—*and keep all you buy*

GENERAL ELECTRIC

672-66-6748

STEEL MILL WELDING*

By Walter K. Simon†

The welding department at the South Works Plant of Carnegie-Illinois Steel Corp. was established during World War I, when welding first came into use for making emergency repairs. Improvements in welding equipment and materials have aided greatly in extending its use since that time. Welded fabrications that formerly were dreams are today almost routine, for welding has now taken its place among the established trades.

One man made up the South Works department at first, but during 1942–43 the department had expanded to include a force of approximately 300 employees. At present the force is limited to about 250, with 40% working in the shop and 60% in the field. As high as 35 women welders have been on the force at one time.

The shop differs from most in that all weldments are layed out, cut to shape, assembled and welded to specifications within the confines of the plant. The transition from raw materials to finished weldments, with the exception of such heavy bending, forming or rolling as may be required, is strictly the function of the welding department. A good portion of the maintenance work is performed in the field, which makes possible continued operation of the mills by eliminating the lengthy and costly dismantling operations required to replace worn or broken equipment. Repair jobs are a sizable portion of both shop and field work.

Fabrication is confined to the shop and at present amounts to about 50% of the shop activities. This phase of operations is one that is increasing by leaps and bounds, with no sign of an ultimate goal. One of the more recent phases of arc welding, the hard facing process, is playing a prominent part in work done by the welding department, with indications that it is still in its infancy so far as applications are concerned. At present the department is hard facing spindles and coupling boxes, pug mill paddles, shear knives, soaking pit tong bits, reheating furnace skid pipes, scrap chutes, guides, side plates, gag press anvils, conveyor buckets, mud gun pistons, bleeder valves, bucket tray lips and numerous other items. Automatic arc welding at present is limited to build-up work that can be rotated in a lathe with a 21-in. swing and a 24-ft. bed.

In a steel mill where most of the equipment is of a heavy nature, Thermit welding has an essential use in joining sections that could not be welded by any other means. During the past 2 yrs. the welding department at South Works has Thermit welded 120 jobs consisting of:

22 open-hearth rams or reels
10 manipulator rams
15 spindles
10 work and back-up rolls
8 pinions
5 ladle car frames
15 stripper tongs
4 gas engine piston rods
6 rail jobs
25 miscellaneous items including shafts, racks, trunnions, roll housings, side guards, etc.

The largest and heaviest of all welded fabrications built in the shop thus far is a Beam mill manipulator, weighing 90,000 lb., with an over-all length of 31 ft 8 in. This had to be fabricated in two parts to stay within the lifting limits of the overhead shop crane.

* Condensation of paper presented before Association of Iron and Steel Engineers, Chicago, Ill., April 3, 1945.

† General Forman, Welding Dept., South Works, Carnegie-Illinois Steel Corp.

LT. J. CUTHBERT OWENS COMMENDED

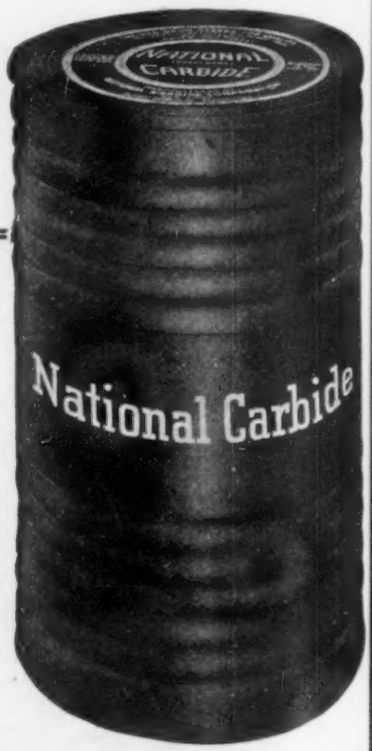
Lt. J. Cuthbert Owens; M.C., U.S.N.R., of Beloit, Wis., was the first medical officer in our armed services to experiment with and successfully use whole blood in a forward invasion area on D-day. The practice of using whole blood is now standard. Dr. Owens has been commended for his work.

Dr. Owens is a recognized authority on beachhead surgical practice because of his varied experiences in at least six major Pacific invasions, including, Tarawa, Kwajalein, Saipan, Guam, Leyte and Luzon.

Dr. Owens' father is James W. Owens, Director of Welding for all Fairbanks-Morse plants, and is located in Beloit, Wis.

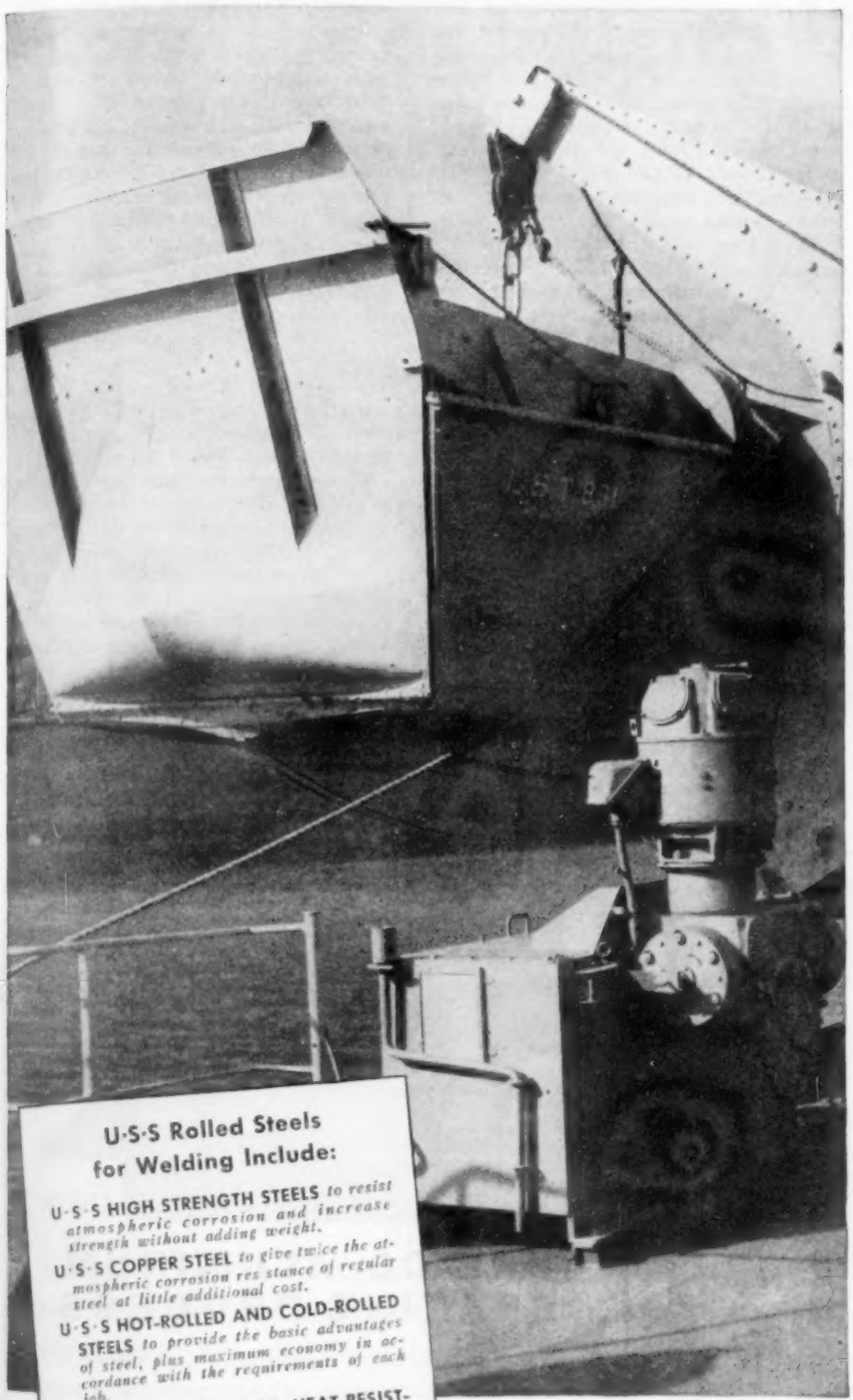
National
Carbide
IN THE RED DRUM

EFFICIENT
ECONOMICAL
DEPENDABLE



FOR WELDING and CUTTING
Use National Carbide in the Red Drum
60 E. 42nd St. NATIONAL CARBIDE CORPORATION New York, N. Y.

FROM SHIP TO SHORE IN *Welded Steel!*



For close work on enemy shores, hordes of these small, self-propelled craft carry men, trucks, artillery and ammunition from larger vessels to the beaches. Their fabrication in quantity is another instance in which the call for new war equipment was met by welded steel—at top speed.

. . .

SUCCESSFUL welders have told us that they *must* have steel of good welding characteristics if they are to turn out quantities of quality work in jig time.

When you work with U·S·S Rolled Steels you have this triple advantage: First, a full line of high quality rolled steels. Second, our technical staff's accumulated knowledge of all kinds of steel. Third, the findings of our welding research specialists, who have made thousands of tests to determine the welding properties of various kinds of steel. Welding engineers and designers tell us this information is of great practical value. It helps them save metal, turn out lighter, stronger work—faster.

Our technical staff will be glad to consult with you, to supply complete, detailed information that is helping countless manufacturers to utilize advanced welding techniques, to maintain quality standards and to meet increased wartime quotas. Drop us a line today, this service is offered without obligation.

U·S·S Rolled Steels for Welding Include:

U·S·S HIGH STRENGTH STEELS *to resist atmospheric corrosion and increase strength without adding weight.*

U·S·S COPPER STEEL *to give twice the atmospheric corrosion resistance of regular steel at little additional cost.*

U·S·S HOT-ROLLED AND COLD-ROLLED STEELS *to provide the basic advantages of steel, plus maximum economy in accordance with the requirements of each job.*

U·S·S STAINLESS AND HEAT-RESISTING STEELS *to assure high resistance to corrosion and heat, and to reduce weight.*

U·S·S CARILLOY ALLOY STEELS—*Special steels for the special jobs of industry.*

USS STEEL — UNITED STATES STEEL

U·S·S ROLLED STEELS FOR WELDING

CARNEGIE-ILLINOIS STEEL CORPORATION, *Pittsburgh and Chicago*
COLUMBIA STEEL COMPANY, *San Francisco*
TENNESSEE COAL, IRON & RAILROAD COMPANY, *Birmingham*
United States Steel Supply Company, Chicago, *Warehouse Distributors*
United States Steel Export Company, New York

UNITED STATES STEEL

GORHAM W. WOODS JOINS LINCOLN ELECTRIC

The addition of Gorham W. Woods to its engineering staff has been announced by The Lincoln Electric Co., Cleveland, Ohio, world's largest producers of arc welding equipment.

Joining the Company as research engineer, Mr. Woods will devote a major part of his time to the development of electrodes, a post for which he is well qualified in view of his many years of experience in the field of chemistry and metallurgy.

A graduate of Rice Institute of Houston, Tex., he received his B.S. degree in Chemical Engineering in 1923.

Mr. Woods was chief chemist of the Hughes Tool Company, of Houston for seven years, and development engineer of the same firm for 12 years. His duties included the design, manufacture and use of oil field tools and supervision of work in various steel mills and oil fields in the southwest and Mexico.

During the past three years he was process engineer of the Dickson Gun Plant, a Hughes-operated concern, where he had charge of the technical aspects involved in the manufacture of cannon by the centrifugal casting process.

A registered professional engineer in the states of Texas and Ohio, Mr. Woods is a member of the AMERICAN WELDING SOCIETY and in 1940–41 was Chairman of the South Texas Section. He has done considerable research and experimental work in the development of welding electrodes, materials and processes. He is also a member of the American Society for Metals and Tau Beta Pi fraternity.

FLOATING FACTORIES REPAIR WARSHIPS IN BATTLE AREAS

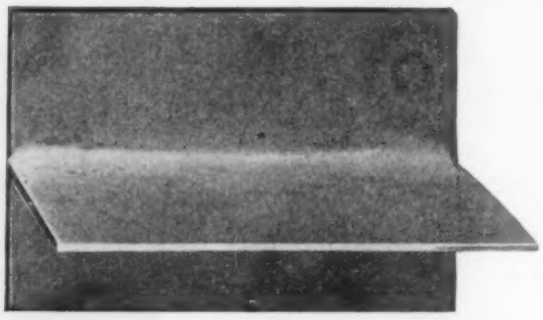
Enough electric equipment to furnish a good-sized factory plus a small hotel is installed on each floating drydock the Navy is using to make emergency repairs of warships far from their most advanced permanent bases, engineers of General Electric disclosed here recently.

These floating factories, recently revealed to be in action, are changing the concept of naval warfare by enabling strategists to plan ocean-going operations without dependence on the availability of fixed bases. Whereas the old static concept of sea strategy required ships to operate within an approximate range of 2000 miles from a permanent repair base, floating drydocks make it possible to establish bases as they are needed and as near the fighting zone as desired.

In operation these mobile drydocks prepare a warship for repair by literally lifting the damaged vessel out of the water, thus giving workmen access to any part of the hull or deck, the same as if the ship were being overhauled on land. This is achieved by admitting water to sealed compartments so that the drydock submerges. When this is accomplished, the damaged vessel is floated over the dock or the dock is submerged under the vessel. Then water is pumped out of the compartments, and the drydock, with the ship under repair now nestling on it in a rack, arises to the surface. In this position, the damaged ship is completely out of the water, with its hull exposed, and examination or repair is made possible.

Though several different models of floating drydocks are presently in operation, the newest and most radical of these is the advanced base sectional type, in which 10 separate units, or barges, are joined together to form a repair dock that

Is this YOUR Cleaning Problem?
Preventing Weld Spatter From Sticking to Surfaces
Before welding operations, apply a thick, heavy solution of Oakite Composition No. 70 to surfaces surrounding welding area—and you will effectively prevent weld spatter from sticking to metal.
This successful Oakite method saves valuable time and effort because it eliminates time-consuming grinding or chipping always necessary when spatter is allowed to adhere. Let us send you complete information. It is FREE on request.
OAKITE PRODUCTS, INC., 18E Thames St., NEW YORK 6, N.Y.
Technical Service Representatives Conveniently Located in All Principal Cities of the United States and Canada
OAKITE
MATERIALS · METHODS · SERVICE
Time Rounds for Victory
CLEANING
FOR EVERY CLEANING REQUIREMENT

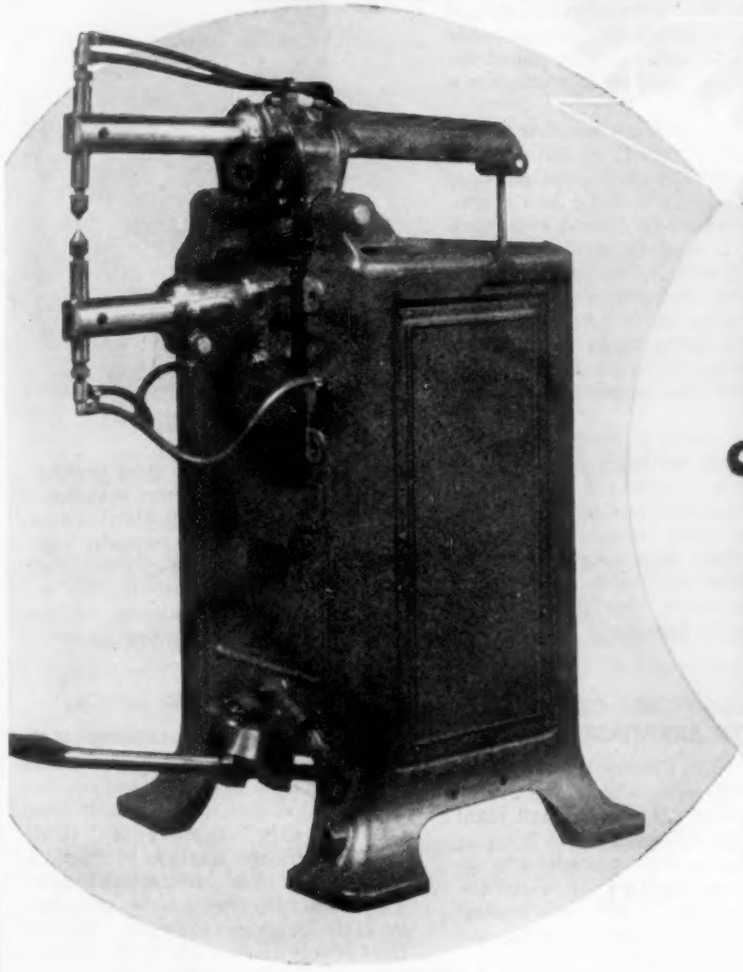


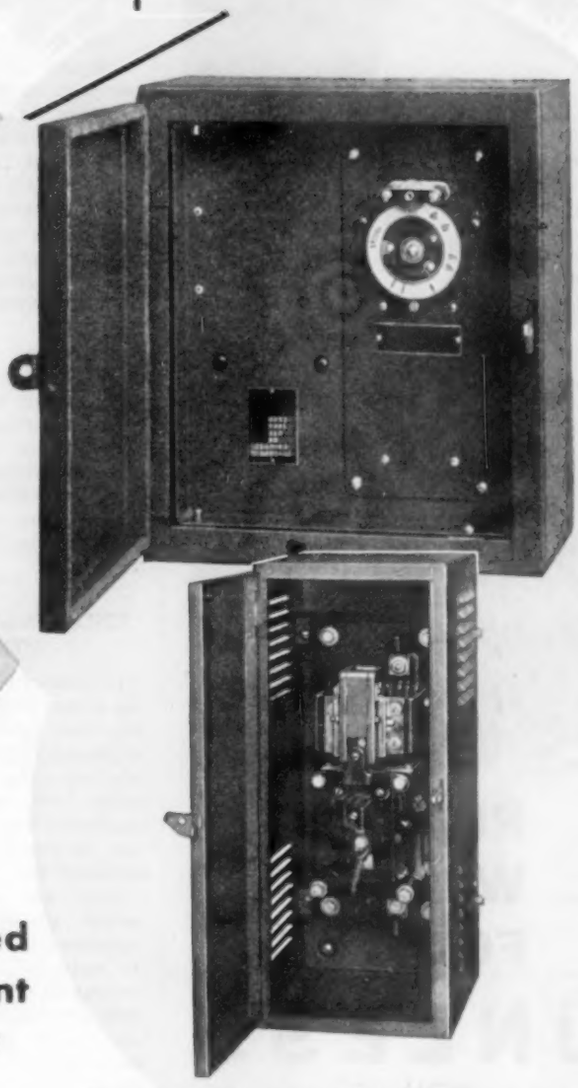
KRE-CO ALUMINUM BRAZING PROCESS

Nothing tricky about joining aluminum when you use our simple process. The gauge of the m tal presents no problem. It is the least costly and most speedy method in use. Operators easily and quickly trained following simple instructions. The process makes brazing possible at a temperature safely below the melting point of the parent metal. Request Bulletin (M 3)

KRE-CO MULTICHEMIC FLUX
DIVISION OF
CHARLES W. KRIEG CO.
52-60 Dickerson St. Newark 4, N.J.

How to modernize Spot Welders for as little as $105.00!





Safront Timer and High-Speed Contactor eliminate human element and assure *uniform* weld quality

Spoilage goes down and production goes up when welding power is controlled *automatically*. And it's a simple matter to equip machines, now in service, with modern timers and contactors for that purpose.

Your nearest Square D Field Engineer will be glad to check up on your present welding equipment. Quite often, such check-ups lead to substantial improvement in quality and output—at very little cost.

Top—**TYPE TBS-1 SAFRONT TIMER** automatically controls duration of welding current. All "live" parts are behind a protective panel. Timer adjustments can be made simply by turning the small knurled wheel on the panel front. Timer dial is calibrated 3 to 100 cycles.

Bottom—**HIGH-SPEED CONTACTOR** closes and opens the circuit to the primary of the resistance welding transformer. It is designed specifically for fast operation and heavy loads. Notice ample ventilation and generous wiring space. Knockouts for conduit entrance are provided in both top and bottom.

SQUARE D COMPANY

DETROIT • MILWAUKEE • LOS ANGELES

REDUCES WELDING FOOTAGE

UNLESS

YOU USE

THERMACOTE

SPATTER-PROOF

COVER LENSES

THERMACOTE spatter-proof, water-proof, always-clear cover lenses pay big dividends in increased welding footage. Prove it with free samples from your nearest dealer.

THERMACOTE CO.

NEWARK CHICAGO
LOS ANGELES PORTLAND

can accommodate a battleship. When this type dock is assembled, the separate barges form a surface nearly as long as three football fields and with side walls rising higher than a five-story building. Each of the sections has a lifting capacity of 10,000 long tons, equivalent to a fleet of 7500 average automobiles. An assembly composed of 7 such sections joined together is large enough to accommodate a cruiser.

Because each barge is a complete unit in itself, as well as a "hotel" for the men who comprise the service crew, great amounts of electricity are consumed. This is generated by diesel-driven generators on each section and is used to operate machine tools, cranes, welders, anchor windlasses, hoists, blowers, compressors, ventilating and refrigerating units and pumps for emptying and filling buoyancy compartments. Electric equipment for these sectional drydocks was supplied by General Electric.

Unable to navigate under their own power, sectional drydocks are towed by other vessels to a protected location and there assembled and put into operation. Their latest repair equipment enables them to overhaul huge warships in short order and either send them back to permanent bases under their power or put them back in the fight.

EISLER ENGINEERING CELEBRATES 25TH ANNIVERSARY

In June of 1920, Charles Eisler founded the Eisler Engineering Company of Newark, New Jersey. It was a small plant employing only a few men, but it's purpose was a big one for it specialized in the design and manufacture of automatic machinery essential to the mass production of incandescent lamps, radio and electronic tubes and accessories.

Eisler was among the first to install special automatic volume production equipment and methods. He introduced the universal coil winding machine for continuous and gap filament coils. Notable among his inventions is the bent exhaust tube process for making tipless house lamps. Year in and out a steady stream of new ideas in automatic machinery continues to flow from the Eisler organization. Most of these have been designed for the lamp industry and include tools and implements necessary for the proper manufacture of incandescent lamps, radio, neon and electronic tubes and accessories.

During 25 years of fundamental and pioneering research, the Eisler organization has grown into a large progressive plant, internationally recognized and distinguished for its many contributions to the radio tube and lamp industries. Standing at the threshold of a new and more promising era in radio advancement the company is commemorating a quarter of a century of service to industry with a special anniversary catalog. This unique catalog is a striking commentary on the historical background and a revealing picture of the Eisler organization. Profusely illustrated with more than 4000 machine and methods illustrations, it is replete with useful information and technical

Charles Eisler

data for the electronic glass working industry, and its numerous branches. It will make an invaluable addition to engineering libraries and company records throughout the country. Those wishing copies are invited to write directly to the Eisler Engineering Company, 760 South 13th Street, Newark 3, New Jersey.

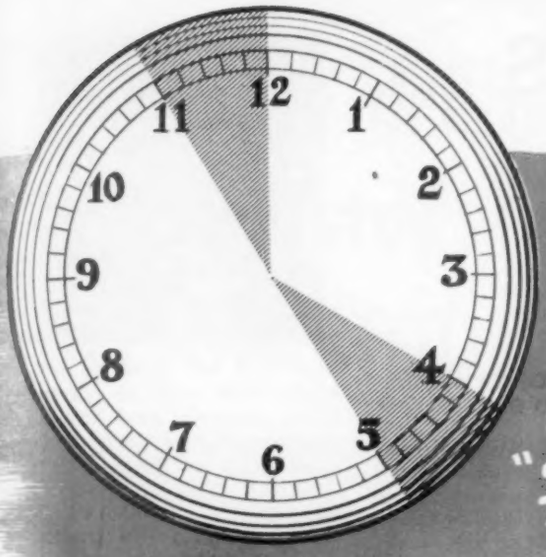
HOBART SALES OFFICE

Announcement is made by the Hobart Welder Sales & Service for a new address of its Oklahoma City office and salesroom. The new location, 518 South Robinson, Oklahoma City, is in charge of C. H. Minton, District Sales Engineer of The Hobart Brothers Co. Mr. Minton has been with The Hobart Brothers Co. for more than 8 yr. in the Oklahoma City area. Mrs. Minton has ably assisted him in the office.

Mr. and Mrs. Minton

The new location provides ample quarters for service, repair parts, and is equipped for welding demonstrations.

Gene Bryan, formerly of Tulsa, has joined the organization in a sales capacity.



PROFITS GO DOWN *in these "Fatigue Hours"*

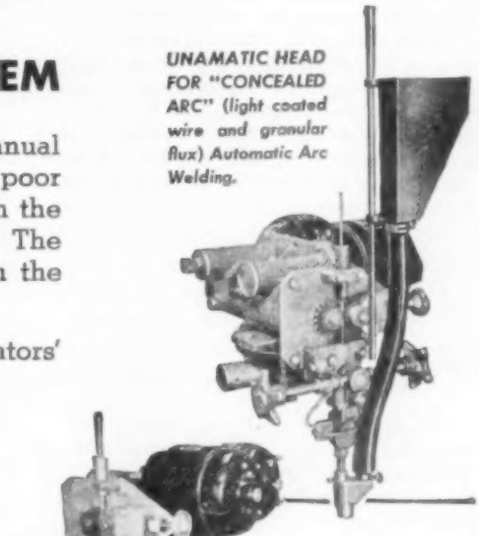
HERE'S HOW ONE MANUFACTURER *(AND THERE ARE MANY OTHERS)* SOLVED THIS ARC WELDING PROBLEM

The general manager of a large Michigan plant, using manual arc welding equipment, discovered that the percentage of poor welds went up considerably between 11 and 12 o'clock in the morning and between 4 and 5 o'clock in the afternoon. The reason was obvious — strain and fatigue began to tell on the operators after several hours of work.

Being an alert general manager, he figured that operators' fatigue not only cut down production . . . it also reduced *profits.* And at that point he decided to take the logical step — install Unamatic Welding — the modern automatic arc welding process.

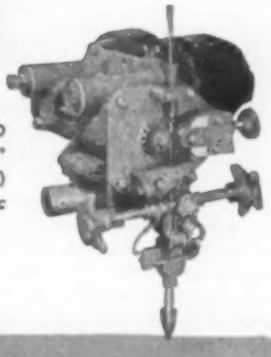
The benefits of this action were threefold: (1) Unamatic Welding enabled this plant to speed production 200-300%, (2) it cut arc welding costs, (3) it resulted in better welding.

We suggest that if *you* want to eliminate the "fatigue hours" in *your* welding departments and obtain these plus advantages, get the facts on Unamatic Welding . . . today.



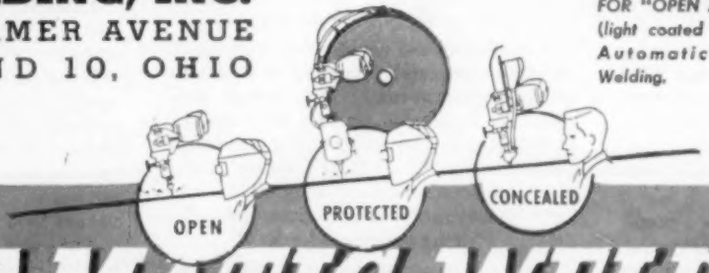
UNAMATIC HEAD FOR "CONCEALED ARC" (light coated wire and granular flux) Automatic Arc Welding.

UNAMATIC HEAD FOR "PROTECTED ARC" (light coated wire and tape), Automatic Arc Welding.



UNAMATICHEAD FOR "OPEN ARC" (light coated wire) Automatic Arc Welding.

UNA WELDING, INC.
1615 COLLAMER AVENUE
CLEVELAND 10, OHIO



UNAMATIC WELDING

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

P & H ARC TIMER

A patent has recently been granted to Erwin C. Brekelbaum and Sol. Oestreicher of the Harnischfeger Corp. of Milwaukee covering the basic functions of the P & H Arc Timer, for use in conjunction with the Production Welding Control System originated by that company, manufacturers of a complete line of arc-welding equipment. The arc timer is an electric clocking device which, connected to the circuit of a welding machine, records the actual time spent by the operator in depositing weld metal. And the system itself is a means of controlling welding procedures, production, quality and cost. Though relatively new, the P & H Production Welding Control System has found a ready acceptance by the welders themselves, providing as it does a just basis for compensation, whatever the wage plan.

A.-C. WELDING MACHINES

J. H. Read, President of Ergolyte Manufacturing Co., 3627 North Lawrence St., Philadelphia, announces a new line of a.-c. arc welding machines that replace their "plug-in" models.

The new machines are built in a modern octagonal all-metal case. The body of the case is a bright red, with black top. The control panel is located on the front to provide easy view of plug-in knobs.

The new machines are called Ergolyte Standard 161 and Standard 251. The big features of these machines are the ease with which the whirlwind air cooling assembly and cyclone automatic arcing assembly can convert either one of these machines to specific welding needs. By the addition of these units to the Standard 161 and 251, four different machines are made. This makes it easy for jobbers to supply the type of machine wanted without carrying large stocks of models. The standard machines plus fan and conversion accessories provide a.-c. welding machines for continuous welding or machines that strike a quick arc with practically any type of rod.

The heavy-duty 300 machine is a stepless type. Built in heavy red octagonal case with black top, the heat gage on the front clearly shows the heat changes. This machine has been tested with a variety of high production heavy welding jobs such as generator bases and landing craft ramps.

ELECTRODE TO WELD COPPER METALS WITH A. C. AND D. C.

The Eutectic Welding Alloys Co. has introduced a new electrode for arc welding. Known as EutecTrode 28, the new electrode is a coated special bronze alloy to be used for the arc welding of bronze, brass and copper.

EutecTrode 28 contains an unusual combination of metals and is shielded with a newly devised flux-coating that makes it suitable for use either on a.-c. or d.-c. current.

The electrode will deposit dense and tough metal that is a good color match to most types of bronzes. It will give the welded area substantially the same corrosion resistance as these various base metals possess. It may also be used for welding copper and brass or joining these metals to steel, cast iron or nickel alloys, and for overlaying steel or cast iron to provide a good bearing surface.

EutecTrode 28 is available in $^1/_8$ and $^3/_{16}$-in. diameters and can be identified by a light green tip.

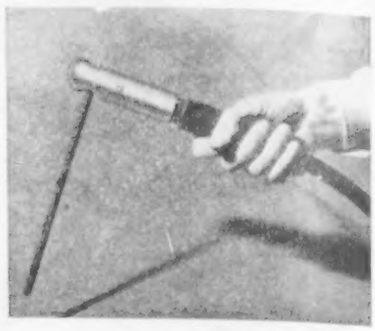
A procedure sheet on the proper use and application of the electrode and a photograph of a welding job done with EutecTrode 28 are available, upon request. Please address all inquiries to Department A-2, Eutectic Welding Alloys Co., 40 Worth St., New York 13, N. Y.

ELECTRODE HOLDER

A new armor-clad (screw type), fully insulated electrode holder has been announced by the Electric Welding Division of the General Electric Co. Designed from the operator's viewpoint the new holder is recommended for use wherever durability, maximum safety and minimum operator fatigue are desired.

A feature of the new holder is its head, which is completely enclosed in a sheath of aluminum armor. This armor protects the insulation, resists weld spatter and eliminates the possibility of accidental contact with the welding circuit. Thus the holder remains clean while in use and lasts considerably longer than insulated holders without armor cladding.

Designed to accommodate electrodes up to and including $^1/_4$ in. in diameter, the holder is easy to use, light in weight (15 oz.) and unusually cool in operation. A slight twist of the hand tightens or releases the electrode. While in use, the



holder firmly grips the electrode at the proper angle and good current contact is maintained. This keeps the holder cool, tends to prevent overheating of the electrode and maintains a uniform melting rate clear down to a stub end. The threads of the push-up rod do not carry current. A soldered cable connection also helps the holder to remain cool. The width of the electrode slot limits the size of the electrode which can be inserted, thus preventing overloading, one of the evils which materially shorten the life of electrode holders.

NEW WELDER'S TRUCK

For the acetylene gas welder who must take his equipment to the place of welding, Palmer-Shile Co., 7109 West Jefferson Ave., Detroit 17, Mich., has provided a convenient means in their new Welder's Truck.

Designed to accommodate one gas and one air cylinder, the new truck cradles to stabilize cylinders and is thus said to provide for easy handling. Truck handles are equipped with cross bar on which Gasaver or torch hanger may readily be mounted. Hooks welded on handles provide a convenient place for hanging gas hose when not in use. Tool box is mounted on swivels so that tools are always in level position.

The new truck is of all-metal, all-welded construction. Frame work is of angle iron and sheet metal. Handles are of heavy tubular steel. Over-all height is 48 in., width 29 in. Wheels are 24 x 2 in. Further detailed information will be supplied by the manufacturer.

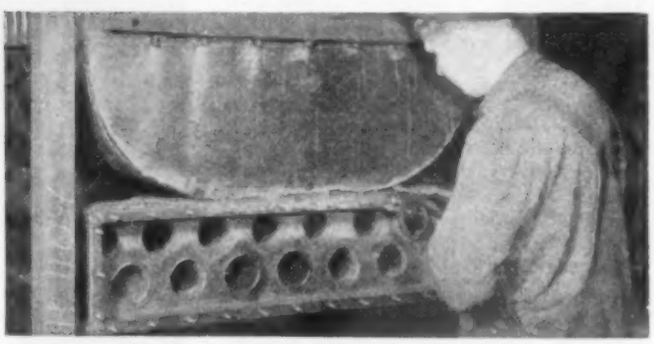
Eliminate drilling and tapping studs with NELSON STUD WELDING!

After layout and centerpunching the studs are welded to the metal. The stud is inserted in the gun chuck, the trigger pulled and a complete, full-fillet weld results. Operators can weld from 500 to 1500 studs in eight hours without difficulty. A template may be used if desired.

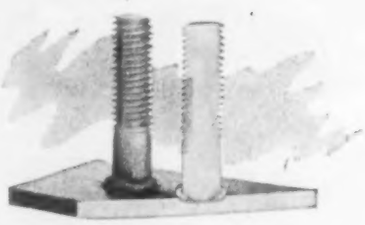
Nelson Stud Welding saves time and material because studs are end-welded to metal without drilling or tapping to secure them. Uniform welds, with full fillet, result every time . . . complete fusion between the stud and metal is obtained in 1/2 second.

The Nelson Stud Welder is *fully automatic* and completely portable. Light in weight and easy to use, it welds effectively in any position. Or it may be operated as a production unit from a fixed jig. Thousands of these automatic welders are now being used in more than 650 industrial plants. No previous welding experience is necessary.

Write today for complete details about the Nelson Stud Welder, catalog and price list.



Inspection covers are an excellent application for stud welding because the studs are easily and accurately located without drilling and tapping. Welds are as strong as those made by any other method.



Cutaway view of stud after welding and etching with Nital shows the complete fusion of the stud to metal. Fillet is not only around outer surface of the stud but weld is a complete fusion of the stud to metal.

For complete details, prices and catalog write:

NELSON SPECIALTY WELDING EQUIPMENT CORP.

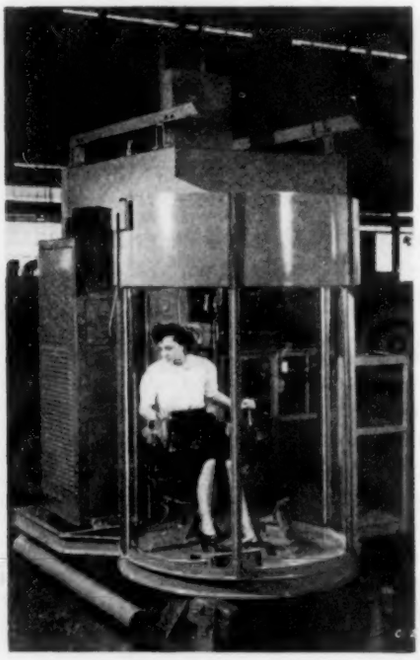
Dept. J, 440 Peralta Ave., San Leandro, Calif.

Eastern Representative: Camden Stud Welding Corp. Dept. 122, 1416 South Sixth Street, Camden, N. J.

CRANE CAB DESIGN

A radical innovation in cab design for overhead traveling cranes has been developed by the Cleveland Crane & Engineering Co., Wickliffe, Ohio, which includes full vision for the operator, comfortable sit-down control and air conditioning.

The cab is the greatest step forward in crane design since the advent of the all-welded steel crane construction also pioneered by Cleveland Crane. Cylindrical in shape it is modern streamlined in appearance. Corners or blind vision spots are eliminated. Ample room is provided with no waste space.



This Revolutionary Cleveland Crane Cab Is 6 Ft. 6 In. High by 4 Ft. 6 In. Diameter and Equipped with Electric Controller & Manufacturing Co. Master Switches and Lintern Aire-Rectifier

The transparent enclosure panels extend to the floor permitting maximum vision in every direction over the area covered by the crane. The panels are of a new plastic which is shatterproof and impervious to certain gases common in many plants that may be injurious to glass.

With this cab, crane operation becomes an easy, sit-down job. Master switches especially designed for magnetic control are located for greatest convenience. Hoist and trolley switches are attached to the right and left arms of the chair. The bridge switch is on the floor and controlled with the right foot. Thus there is a definite control job for each of the operator's hands and feet, but none of his limbs need serve a double duty as in most conventional cabs.

An air-cooled air-conditioning unit, especially designed for this cab provides fresh clean air at any normal temperature desired and gives protection against objectionable gases, dusts and fumes. The unit attached to the cab illustrated is for use where temperatures do not exceed 140°. Adequate sealing and insulation is provided to assure against excessive losses.

A novel feature is the traveling platform which serves both as vestibule to the cab and a means for easy access to the entire exterior side of the window for cleaning purposes. Safety locks on both platform and cab door prevent operation of either except when platform is in proper position.

This new cab is a self-contained unit that may be furnished with any new crane employing magnetic control and it may be applied to existing cranes of any make.

ALL-POSITION WELDING WITH A. C.

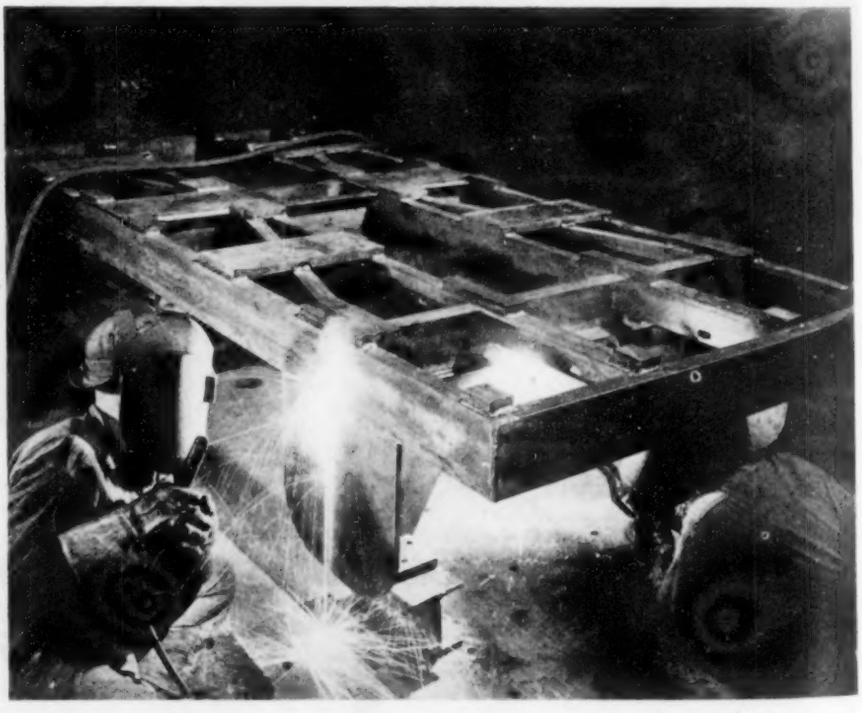
The use of a.-c. welding, particularly for vertical and overhead work, has been hampered by the lack of an all-position a.-c. electrode capable of producing highest quality weld metal. Long a research project, an a.-c. electrode, known as the ACP, has emerged from Westinghouse laboratories; it meets the requirements of the U. S. Navy Department Bureau of Ships and the standards for welding set by various associations. The new electrode includes an arc pacifier that prevents excessive spatter loss during the negative half cycles and an arc stabilizer to aid in re-establishing the arc after each current zero.

For best performance on vertical and overhead arc welding, a high-organic electrode coating is used. This coating provides an envelope of burning gas that keeps the oxygen and nitrogen in the atmosphere from contaminating the weld metal. This type of coating leaves but a scanty slag over the deposited metal that does not interfere with welding. Curiously, this high-organic coating works in a satisfactory manner when the current flows in one direction but not the other. Obviously, d.-c. welding is easily performed in these positions but alternate half-cycles of a.-c. welding would be unsatisfactory. This restriction has impeded the progress of the much simpler a.-c. welding for some fifteen years. Good reverse-polarity (electrode positive), all-position, d.-c. electrodes have been available for years. The secrets of the prerequisite coating for all-position, a.-c. welding began to unfold some two years ago.

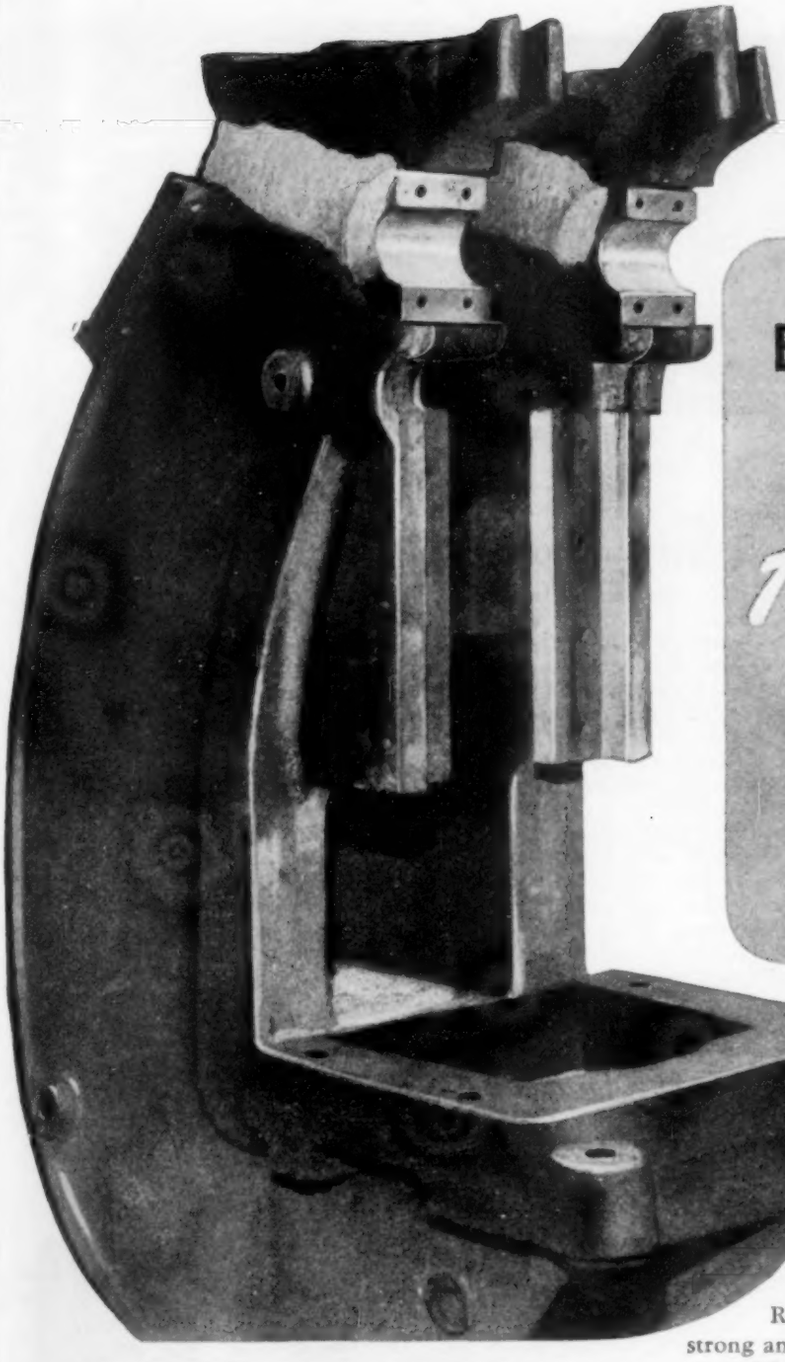
The coating of an a.-c. welding electrode must provide a number of factors, indispensable to a satisfactory weld. Protection from atmospheric gases, scanty slag, no slag interference with the arc, adequate drive and penetration without undue spatter loss, are some of the factors dependent upon a proper coating.

In addition, two factors of great importance in a.-c. welding are arc stabilizing and "arc pacifying." When the current goes through current zero, the arc is extinguished and the coating must provide an enveloping atmosphere of highly ionized gas so that the arc will restrike for the succeeding half cycle. Also, assuming the current during the first half cycle has been flowing in the reverse-polarity direction (the direction in which high-organic coatings operate best), the correct amount of "arc pacifier" must be provided for the next half cycle to prevent excessive spatter loss, at the same time avoiding loss of drive and penetration.

The availability of an electrode capable of producing welds in overhead and vertical positions, having the high ductility and freedom from porosity necessary to meet the most rigid code requirements, has further accelerated the use of a.-c. welding.



Including an Arc Pacifier That Prevents Excessive Spatter Loss During the Negative Half Cycles and an Arc Stabilizer to Aid in Re-establishing the Arc After Each Current Zero, a New A.-C. All-Position Welding Electrode Now Makes Possible Overhead and Vertical Welding Such as This



Busy on Bomb Parts, Fractured... TOBIN BRONZE WELDED in 22¼ Hours

ANOTHER EXAMPLE of how Bronze Welding is helping keep vital production tools in action, is this punch press used in producing bomb parts.

Repairs to the cracked frame had to be strong and dependable . . . *and made with minimum delay.* So the Wayne Welding Supply Company, Inc. of Fort Wayne, Indiana used Tobin Bronze*. A total of 60 pounds of ¼-inch rod was required . . . and the work was completed . . . preparation, preheating, welding and finishing . . . in only 22¼ hours.

"Don't scrap it . . . Bronze weld it," is a slogan worth remembering. How to put it to work in your shop forms part of the practical information presented in Publication B-13. This publication also gives detailed information on the complete line of Anaconda Welding Rods. Write for your copy today. 65110

*Reg. U. S. Pat. Off.

What's YOUR experience with BRONZE WELDING?

Tell us what you've accomplished with Bronze Welding in the way of repairs, building up of worn surfaces, production operations, etc. We'll gladly publicize items of general interest for the benefit of all.

THE AMERICAN BRASS COMPANY
General Offices: Waterbury 88, Connecticut
Subsidiary of Anaconda Copper Mining Company
In Canada: ANACONDA AMERICAN BRASS LTD., *New Toronto, Ont.*

Keep Faith With Your Fighters and Yourself! Buy War Bonds

ANACONDA

Anaconda Welding Rods

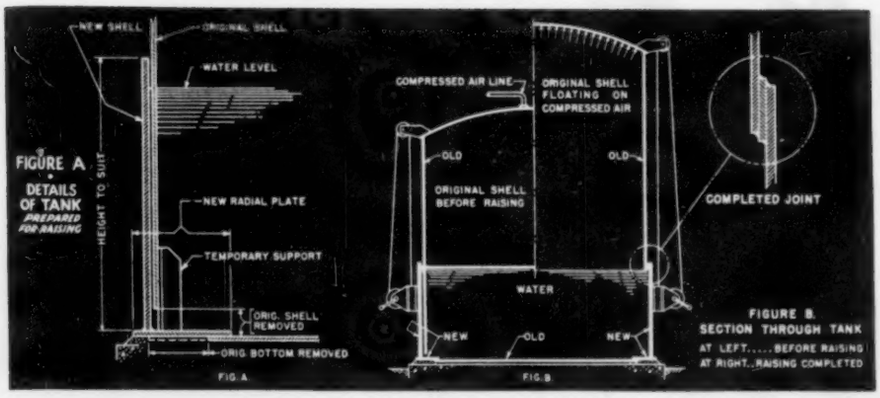


FIGURE A. DETAILS OF TANK PREPARED FOR RAISING

FIGURE B. SECTION THROUGH TANK AT LEFT.....BEFORE RAISING AT RIGHT..RAISING COMPLETED

Enlarging Storage Tanks

ENLARGING STORAGE TANKS

A new method by which liquid storage tanks may for the first time be enlarged to as much as twice initial size without dismantling the original structure has been developed by the Stacey Bros. Gas Construction Co., Cincinnati, one of the Dresser Industries.

The old tank is literally boosted to new capacity height, as new rings are added at the base by a patented process which makes use of virtually all of the original structure in assembled form. Such re-use, along with the utilization of the original foundation and the minimum dislocation of connections, contributes much to the economy of the process as well as to the speed with which a job may be completed.

Providing for the first time an alternative to new tank construction to increase storage capacity, the Stacey Bros. method will be particularly useful where facilities are crowded and there is room only for expansion upward.

As much as 100% additional capacity may be added by Stacey men, who cut the existing tank shell at the base, add new radial plates and build a new shell around the old structure to give the desired height. Water is then run into the tank up to the new shell level, so that compressed air may be introduced to float the old cover shell up to the new level. Various controls hold the tank steady and level to $^1/_{16}$ in., while 4-in. filler plates are inserted between the shells, and the two units are tack welded in place.

When air pressure is released, and the water drained from the tank, the two shell sections and fillers are completely seal welded on the outside. Inside, the old shell is trimmed and welded at intervals around its circumference, and the enlarged tank is ready for connections and service.

Originally developed to obtain better buoyancy control of petroleum storage tanks in areas subject to flood, the new method can be used to build up tanks having either umbrella type roofs, or roofs supported by center columns. The inherent economies of this method are expected to be of widespread significance in the busy days ahead.

MAGNAFLUX INSPECTION

A new unit for magnetic particle inspection, known as the KH-2 unit, has just been introduced by Magnaflux Corp. Of radically different electrical design this Magnaflux unit is particularly well suited for inspection of welds, castings, large forgings and machinery parts, and is recommended for general use in foundries, welding shops, oil refineries, shipyards, etc.

This unit is unique in effectiveness. It permits detection of deeper subsurface discontinuities and enables one to distinguish between laminations and segregations in rolled plate. Welds designed with open roots can be inspected without interference of nonrelevant indications. This unit may be used to locate shrinkage cracks, hot tears, blowholes, porosity, etc., in castings; thermal cracks, lack of penetration and fusion, slag inclusions and other discontinuities in welds; laps, bursts, cold shuts, etc., in forgings; and fatigue cracks in machinery parts

The design of the new KH-2 Magnaflux unit is based on both practical experience and extensive laboratory research. Minimum size, weight and maintenance with extreme durability are featured. It furnishes half-wave, single-phase, rectified output for d.-c. magnetization and also high-amperage, low-voltage a. c. for both magnetization and demagnetization. It is extremely versatile and requires no auxiliary equipment except the Magnaflux Powder Blower.

Additional information and complimentary copy of the article "Routine Inspection and Salvage of Machinery Weldments..." by James W. Owens may be obtained by writing to Magnaflux Corp., 5900 Northwest Highway, Chicago 31, Ill.

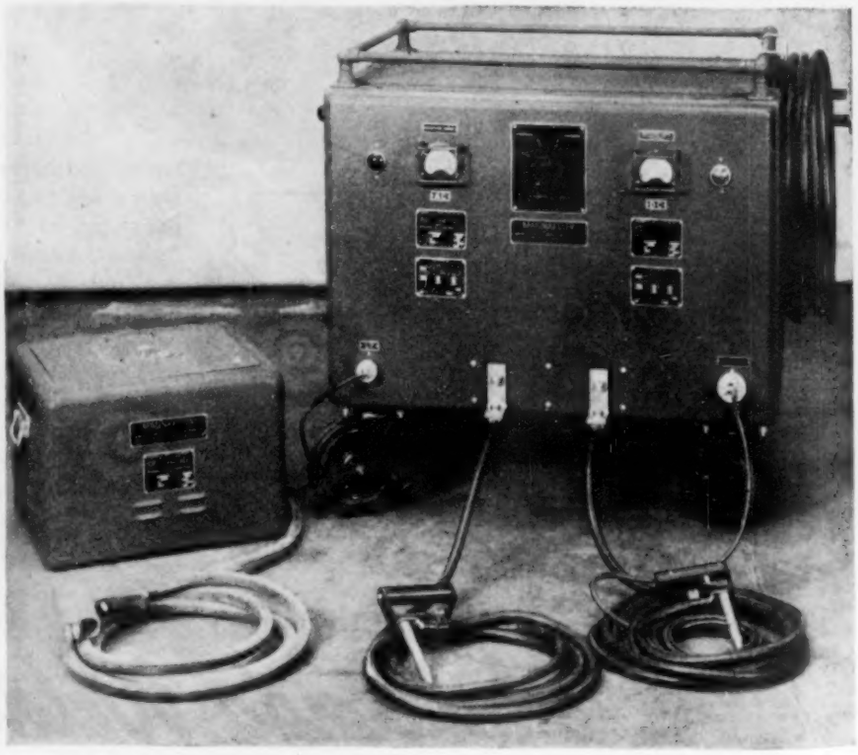
SAFETY CHART

A new, invaluable reference chart for welders, which points out the proper shades of filter lenses to wear for different types of welding operations, is announced by the American Optical Company. Copies of the chart can be secured free of charge by writing the concern direct at Southbridge, Mass.

The new chart will help simplify and speed up the welder's work in addition to guarding his eyesight. For example, in oxyacetylene torch cutting and welding, the shades of filter lenses are classified according to whether the cutting or welding is light, medium or heavy.

Of great importance to the welder, the shades for electric welding are classified according to the different diameters of the welding rods; consideration has also been given to the use of carbon, helium and atomic hydrogen arcs.

Wherever possible, a choice of shades is given because of each individual's varying sensitiveness to light. The chart is printed on substantial lightweight cardboard.



Especially.. FOR HORIZONTAL FILLET WELDS ON MILD STEEL— RACO 20 ELECTRODES

Used particularly in positioned production welding of a wide variety of plate assemblies—in shipyards for welding bulkheads, hatch girders, deep tanks, etc. . . . in other industries for welded car frames, roll pipe welding and welded machinery. RACO 20 Electrodes may be used with equal success on direct or alternating current.

These electrodes meet the requirements of:

A.W.S.—A.S.T.M. Specification A233-43T, Type E-6020
U. S. Navy Bureau of Ships Specification 46E3 (INT)

Grade II, Class 2

Other RACO Mild Steel Electrodes:

RACO 5—For deep grooves. A.W.S. E-6030
RACO 7—All position, reverse polarity. A.W.S. E-6010
RACO 8—General purpose, poor fit-up. A.W.S. E-6012
RACO 11—All position, A.C. A.W.S. E-6011
RACO 13—General purpose, light gauge. A.W.S. E-6013

All RACO Electrodes must comply with the highest standards of quality. Convince yourself—send for samples

The REID-AVERY COMPANY
INCORPORATED
DUNDALK • BALTIMORE 22 • MARYLAND
SINCE 1919 PRODUCERS OF ARC WELDING ELECTRODES AND WELDING RODS

SECTION ACTIVITIES

BOSTON

The Annual Meeting of the Boston Section was held on April 9th at the Engineer's Club. C. E. Betz, Vice-President, Magnaflux Corp., Chicago, spoke on "The Place of Magnetic Particle Inspection in the Welding Field," and Arthur N. Kugler, Applied Engineering Department, Air Reduction Sales Co., New York, spoke about 'Electrodes, Their Classification and Use."

The following officers were elected by ballot to serve for the year 1945-'46: *Chairman*—P. E. Kyle, Mass. Institute of Technology, Cambridge; *Vice-Chairman*—H. G. Austin, Lukenweld, Inc., Boston; *Sec.-Treas.*—P. N. Rugg, Boston Edison Co., Boston; *Trustee*—L. F. Jackson, The Linde Air Products Co., Boston. *Directors* (for 2 yr.)—G. A. Ross, General Electric Co., Lynn; E. L. Sheerin, The Linde Air Products Co., Boston; H. H. Stahl, The Lincoln Electric Co., Boston.

CHICAGO

The April meeting of the Chicago Section was held on the 20th. B. L. Wise, of the Federal Machine and Welder Co., discussed "Recent Resistance Welding Developments." Pre-Meeting Movies "On the Air" and "Electronics at Work" were shown through the courtesy of the Westinghouse Electric Corp.

CINCINNATI

James K. Ross, Design Engineer, Cincinnati Milling Machine Co., gave a Discussion of Welding Costs, at the April 24th meeting. Movies "Back to Normal" and "Air Battles, January 1st" were shown following the talk.

CLEVELAND

J. F. Wagner, Vice-President, The Burdett Oxygen Co., 3300 Lakeside Ave., Cleveland 14, Ohio, has been appointed Secretary-Treasurer of the Cleveland Section.

COLUMBUS

The May meeting of the Columbus Section was held on the 11th. R. W. Holmes, Service Engineer for Curtiss-Wright spoke on Helldivers in action in the South Pacific Theatre of War. A Navy film "Aircraft Welding" was shown.

DETROIT

The speaker of the April 4th meeting was J. W. Cable, Sales Manager of the Induction Heating Corp., New York City, who discussed induction heating and brazing. Mr. Cable was introduced by the honorary chairman, E. L. Kavanaugh, Senior Engineer, Power Sales Division of the Detroit-Edison Co. Mr. Kavanaugh advised the meeting of the Induction and Dielectric Heating demonstration sponsored by his company, to be held April 10th, 11th and 12th. He gave a brief history of the development and use of induction heating before introducing the speaker.

Mr. Cable described how induction heating uses high-frequency electrical current to rapidly heat closely controlled areas to provide sufficient heat to melt various bonding materials from soft solders to copper. Slides and brazed specimens demonstrated accomplishments achieved, using this method of heating. A lively question and answer period followed Mr. Cable's excellent talk.

The technicolor film "The Alcan Highway" presented by Lt. Col. W. H. Harvie of the U. S. Engineers Corps opened the meeting.

A broad scale survey of welding technology was presented May 4th at the Second Annual Welding Conference of the Detroit Section, comprising an afternoon and an evening session.

Three papers were offered in the afternoon program, which was under the technical chairmanship of L. A. Danse, chairman of General Motors Corp. metallurgical committee. The first of these was a paper by G. O. Hoglund, welding engineer Aluminum Co. of America, on "Methods of Joining Aluminum." Mr. Hoglund described the various classes of welding which could be utilized in specific situations where aluminum was the metal to be joined, and described a number of new uses to which aluminum is being put. Charles H. Jennings, of Westinghouse Electric & Mfg. Co. Research Laboratory, spoke on "How to Control Welding Distortion." One of the main points he brought out was that a definite welding procedure is necessary in all shop work even though full advantages are taken of fixtures and preforming. He described distortion as an inevitable result of cooling.

The third paper of the afternoon was on "Resistance Welding Laboratories and Instruments," presented by R. T. Gillette, welding engineer of General Electric Co. Mr. Gillette declared that a well-equipped laboratory must be prepared to make metallurgical studies, macro and micro photographs, X-rays and also X-ray testing to determine weld soundness. The laboratory also should have facilities for developing data on preheating and postheating, together with equipment for physical, chemical and spectrographic testing. At the evening program the dinner speaker was C. M. Ripley, power engineer of General Electric Co., who offered a nontechnical presentation of the broad sphere occupied by electricity, and the effects of its adaptability and low cost. Following dinner, for which the toastmaster was Austin Grant, Detroit radio commentator, there was music and dancing.

New officers for next year were announced during the evening. George J. Friebel of Harnischfeger Corp. becomes *chairman*, A. H. Lewis of Swift Electric Co. is *first vice-chairman;* A. J. Last of Welding Sales & Engineering Co. is *second vice-chairman;* G. N. Sieger of S. M. S. Corp. is *secretary-treasurer;* and Edgar B. Brown of the American Brass Co., who served as chairman of the Second Annual Welding Conference of the Detroit Section, is *assistant secretary-treasurer*.

INDIANA

The April meeting of the Indiana Section was held at the Riley Hotel, Indianapolis, April 27th.

E. F. Holt, Research Engineer, P. R. Mallory & Co., Inc., gave an interesting talk on "Comparison of Copper Base Materials Used in Resistance Welding."

A technicolor film, "The Magic Wand of Industry," which was produced by the Lincoln Electric Co., and which was recently released by the Navy, was shown.

KANSAS CITY

H. W. Sharp, Metallurgist of the Stoody Co., was the speaker at the April meeting. His subject was "Micro-Structure of Hard Facing Alloys." He explained the application of hard facing alloys, the type and construction of rods available, and illustrated by slides of micro photographs the structure of the deposited material.

A sound film "What Makes the Battle" was presented.

LEHIGH VALLEY

The final meeting of the 1944-45 season was held on May 7th at the Hotel Bethlehem, Bethlehem, Pa. After the dinner, the Eastman Kodak sound film on "Color Photography" was shown.

The following officers were re-elected for next season: *Chairman*—J. W. Kenworthy, Mack Manufacturing Corp.; *Vice-Chairman*—G. E. Doan, Lehigh University; *Secy.-Treas.*—Julius Naab, Ingersoll-Rand Co. *Incoming Directors*—H. O. Hill and Q. E. Charlesworth, Bethlehem Steel Co.

The technical paper on "Steel Castings in Welded Construction" was prepared by C. W. Briggs of the Steel Founders Society of America and read by J. W. Juppenlatz of the Lebanon Steel Foundry. The paper did not discuss the controversial subject of castings versus welded construction but did discuss the repair and assembly of castings by welding.

After the technical program refreshments were served.

How I tipped Smitty off to the new Murex HTS

SMITTY, our arc-welding super, let out a roar that must have carried clear up to the Front Office, waking up half our Brass Hats.

"I'm the boy," he squawked tragically, "that everything happens to! Kindly look at that assembly, Miss Davis."

I kindly looked at the assembly. It was a part he'd just welded. It had cracked.

"It's busted," I said brightly.

"You're —— right it's busted!" Smitty yelled, forgetting I'm just a lady welder, and not a night club babe who is used to such fascinating language. "And I'd like to bust the guy that thought this steel could be welded in the first place. Now what do I do?"

"Being new around here," I said calmly, "I wouldn't know. But I can tell you what the arc-welding super I used to work for did whenever he got in a jam. He put in a hurry call to Metal & Thermit, who make about thirty electrodes they call Murex, and a Murex man would come on the run with the answer."

Smitty began to flare up, the way men usually do when they ask your advice and you give it. But one more look at the cracked welds cooled him off. He called Metal & Thermit.

The Murex man was out the next day with something he called the new Murex HTS or High Tensile Steel rod. In a jiffy he had on welding gloves and a helmet and was making welds without cracks or porosity.

"*This new Murex HTS,*" I heard him tell Smitty, "*was designed to fill a definite need. Because of its moderate penetration and low pick-up of alloys it is an ideal rod for use on many hard-to-weld steels, particularly those of the high carbon and high sulphur types. And it's an all position rod that can be used on lots of jobs where we used to have to weld with stainless steel.*"

The upshot was that Smitty ordered 3000 pounds of the new Murex HTS on the spot. And when I left for the day, he and the Murex man still had their heads together over the new Murex Wall Chart, which gives all the data on Murex's thirty-odd electrodes. I advise you to write for one to tack up in your department. And to save a lot of excitement and agony when some new arc-welding problem comes up, tip your boss off to call or drop a line to:

METAL & THERMIT CORPORATION
120 BROADWAY, NEW YORK 5, N. Y.
ALBANY • CHICAGO • PITTSBURGH • SO. SAN FRANCISCO • TORONTO

We sort of dreamed up Miss Davis. But Smitty's problem was only too real: it involved Speedcase steel analyzing .20 carbon, 1.25 manganese, .02 phosphorous, .03 silicon and .25 sulphur. The new Murex HTS rod solved it for him—and is solving lots of other arc-welding problems under conditions mentioned in italics above.

MUREX Electrodes

LOS ANGELES

April Dinner meeting of the Los Angeles Section was held April 19th, at Scully's Restaurant. Pre-dinner showing was made of the British produced short "Air Battle."

The speaker, C. C. Pendrell, District Manager, Haynes-Stellite Co. presented a paper titled "Welding Structures of Hastelloy Alloys." This paper consisted of a compilation of the nation's manufacturer's experiences in Hastelloy fabrication. Slides clearly illustrated the various steps in and methods of construction with sketches and photographs. C. G. Chisholm, Chemical Engineer of Haynes-Stellite Co. took over the discussion and gave "all the answers" including a "ringside" account of the development and application of Hastelloy in the 100 Octane program.

Sectioned specimens were presented for personal examination by each of the group.

Preview showing for the West Coast was made of the film "Magic Wand of Industry—Arc Welding." This film produced by Lincoln Electric Co. was acclaimed a natural for selling arc welding to the layman.

Concluding feature on the program was reshowing of film "Air Battle."

LOUISVILLE

April dinner meeting, the "grand-finale" of the current seasonal activities was held Tuesday, April 24, 1945, with a dinner meeting attended by 150 members and guests with a very popular subject "The Welding of Aluminum" being presented by Alcoa's G. O. Hoglund. A "sound" motion picture "How to Do It" together with lantern slides plus the knowledge and personable Mr. Hoglund's interpretation of the subject really put the final touch to the aforesaid "grand-finale."

Our "dinner-toaster" Bruce Dudley, President of the Louisville Baseball Club of the American Association, entertained with an analysis of the "Colonels" and their individual characteristics which left no doubt in the audience's mind that Louisville has won the pennant—at least on paper— and all we need to do now is to follow through.

The invited guests seated at the executives' table of nine were: Colonel Kelley Lewis of the Indiana Ordnance Works, Lt. George C. Watt, Jeffersonville Boat & Machine Co., and Dr. G. C. Williams, University of Louisville.

R. E. Fritsch, our veteran Master of Ceremonies had on display the extraordinary paintings of "Twelve War Subjects" by James Sessions which have been recognized by the Metropolitan Museum of Art, also the Chicago Art Institute. Rudy being President of Tube Turns, Inc., the owners, the Display was allowed by special arrangements. Each guest was presented with a "Calendar-ized" copy of each painting.

Theodore H. Lewis, Chairman presented to Mr. Hoglund (Alcoa) "A certificate of appreciation" appropriately framed for wall decoration. G. W. Plinke also received an award for his composition entitled "A Tribute to the American Welding Society."

MARYLAND

At the March Meeting, A. C. Earlbeck, Welding Technician, presented the paper, "The Future of the Welding Operator in the Baltimore Area." Mr. Earlbeck cited the possibilities in further designing for welding and the need for continued educational effort along these lines. The demand for operators hinges upon this expansion of the welding art. The need for competent job shop operators in the various communities, will, no doubt, increase.

The discussion brought out the fact that many of the war-job trained people are now returning to their home towns to open shops of all kinds. It was interesting to note the opinion that many of these people will return to farms and maintain their own welding facilities where possible.

At our April Meeting, Lt. L. B. Sykes, U.S.N.R., Bureau of Ships, Research and Standards Section, presented a paper, "Some Metallurgical Factors Which Influence the Weldability of Steel." Lt. Sykes' paper was, in a sense, a critique on the efforts of manufacturers of equipment, rods, and upon the nature of tests to prove their adequacy for the welding job.

J. C. Cumberland, our Chairman, was not present, as he was undergoing a minor operation in the hospital.

Two of the General Electric Co.'s films, "Excursions in Science" were shown for educational entertainment.

MILWAUKEE

Leon C. Bibber, Welding Engineer, Carnegie-Illinois Steel Corp., Pittsburgh, Pa., presented the welding address on "A Study of the Longitudinal Tensile Properties of Large Specimens Simulating Ship Construction," at the April 27th meeting.

NEW JERSEY

Charles Kandel of Craftsweld Equipment Corp., and Charles Cooper of Metal & Thermit Corp., were the guest speakers at the April 17th meeting. Their subjects were on Underwater Welding and Cutting in Salvage and Industrial Operations. Demonstration models of diving gear gas cutting torches and arc-oxygen electrode holder added to the interest of the papers. A film "Bombing of Pearl Harbor" was also shown. One hundred forty-two members and guests were present.

NORTHERN NEW YORK

George N. Sieger, President of S-M-S Corp., Detroit, spoke on Resistance Welding, at the April 26th meeting of this Section.

OKLAHOMA CITY

April meeting held on the 19th was addressed by H. W. Sharp, Metallurgist of Stoody Co., Whittier, Calif. Mr. Sharp's address "Micro-Structure of Hard-Facing Alloys" was completely illustrated with slides and actual specimens.

PEARL HARBOR

The newly formed Pearl Harbor Section has announced the election of the following officers: *Chairman*—Howard J. Shanley, *Vice-Chairman*—Norman J. Woods, *Secy.-Treas.*—David E. Woodling, *Jr. Past-Chairman*—Roncisco H. Davis. *Directors*—Joseph Waldman, Armand J. Champagne and Stanley Jurczynski.

Since the above election Mr. Woodling, the Secretary-Treasurer, has been transferred and Donald B. Towler of Honolulu, Hawaii, has been appointed as Acting Secretary-Treasurer.

PHILADELPHIA

Regular meeting held on April 16th. Professor J. T. Norton of Massachusetts Institute of Technology, spoke on "Residual Stresses in Welds."

The following are the members of the Philadelphia Executive Committee for 1945-46: *Chairman*—Arthur A. Holzbauer, Sun Shipbldg. & D.D. Co., Chester; *Vice-Chairman*—Harold B. Seydel, Air Reduction Sales Co., Philadelphia; *Treasurer*—William F. Carson, Carson & Carson Philadelphia; *Secretary*—K. W. Ostrom, Arcos Corp., Philadelphia; *Jr. Past Chairman*—George R. Johnson, The Lincoln Electric Co. *Term Expires 1946:* T. M. Jackson, W. S. Wagner. *Term Expires 1947:* H. J. Irrgang, I. C. Frederick. *Term Expires 1948:* Harry W. Pierce, A. B. Gordon, O. J. Pearre.

PITTSBURGH

Nearly 100 members and guests attended the March 21st meeting of the Pittsburgh Section and heard William Watts, Research Metallurgist, Falk Corp., Milwaukee, discuss "Steel Castings, Their Use in Weldments."

Mr. Watts discussed the engineering and metallurgical properties of cast steel suitable for welding; the factors of design and specifications required to insure satisfactory castings for welding, and the economies of steel castings for weldments, including typical examples.

It was shown that cast steel has identical physical metallurgical and welding properties as those of rolled and forged steels of similar composition. With proper attention to design, sound castings can be secured which can materially aid in reducing the production time and costs of weldments. Numerous examples of the effective use of steel castings in industrial applications were illustrated by slides.

PUGET SOUND

The following officers were elected for the coming year at the April 25th meeting of the Puget Sound Section: *Chairman*—Prof. Gilbert S. Schaller, *Vice-Chairman*—Floyd Mathews, *Secy.-Treas.*—Robert E. Russell. *Executive Board* (1-yr. term)—George Tepley, Jack Ward, George Brett; (2-yr. term)—I. C. Bradway, Carlos Flohr, H. O. Van Slyke.

The meeting was preceded by the usual question box discussion with Joe Holt presiding.

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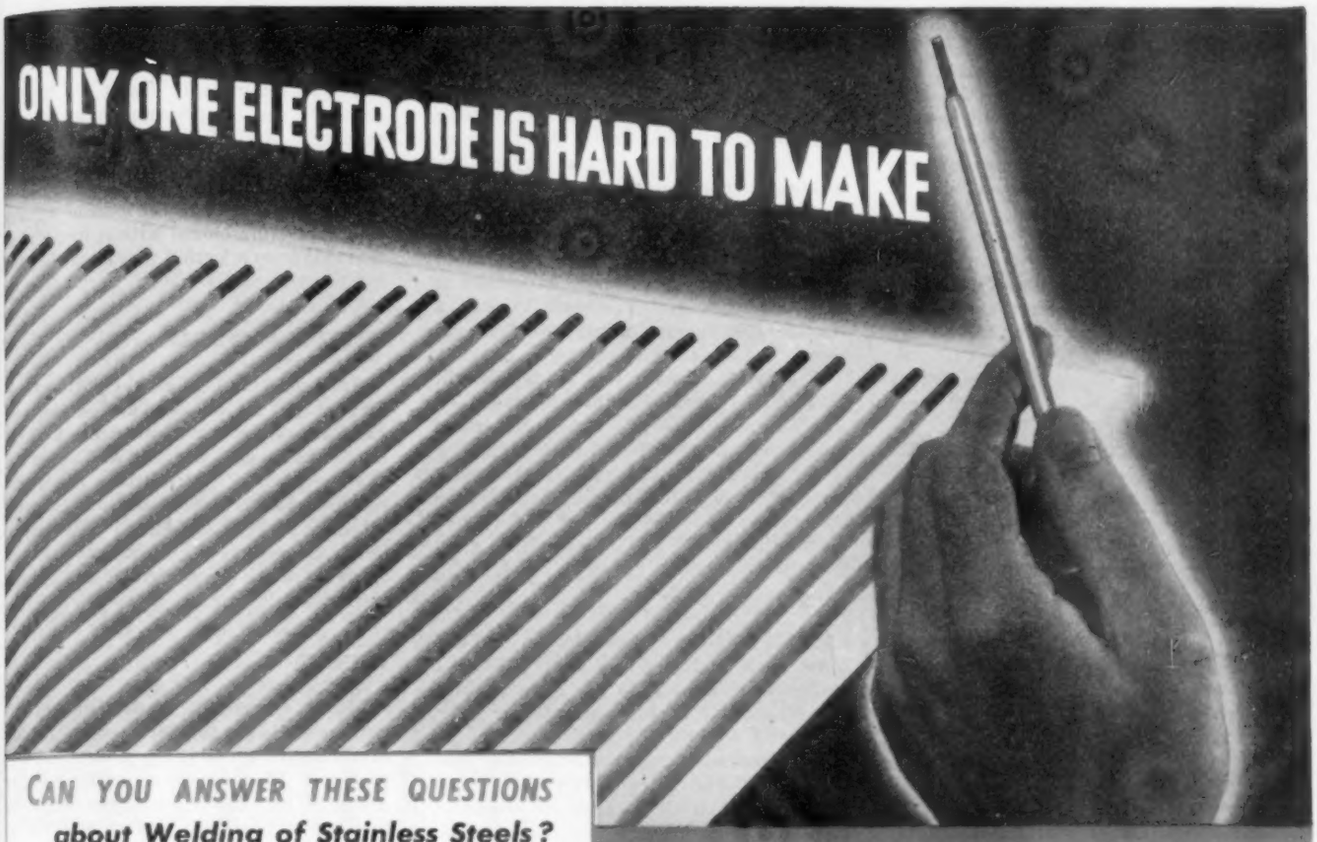

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CAN YOU ANSWER THESE QUESTIONS about Welding of Stainless Steels?

	TRUE	FALSE
11. Molybdenum is added to stainless steels to increase their scaling resistance at elevated temperatures.	☐	☐
12. Not all stainless steels are classified by metallurgists as "austenitic."	☐	☐
13. Stainless steel electrodes are used on reverse polarity because they will not operate satisfactorily on straight polarity.	☐	☐

Answers: 11. False; 12. True; 13. True.

Questions 1 to 10, inclusive, have appeared in preceding advertisements. Other questions will appear next month. Watch for them!

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A limited number of these valuable booklets are still available for distribution. We shall be glad to send you a copy upon request. Ask for "Things to Know about Welding Stainless Steel."

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WELDING ELECTRODES . . . COMMERCIAL CHAINS . . . TIRE CHAINS

The speaker for the evening was William A. Snyder of the Engineering Dept. of the University of Washington, who gave one of the outstanding talks of the year in a discussion on the fundamentals of welded machine design. A very important part of his talk referred to the amount of distortion and residual stress caused.

SAINT LOUIS

On April 13th, the St. Louis Section of the AMERICAN WELDING SOCIETY held its regular monthly meeting at the Engineers' Club of St. Louis, and our speaker for the evening was H. O. Westendarp, Jr., Electric Welding Division, General Electric Co., Schenectady, N. Y.

Mr. Westendarp's subject for the evening was "The Selection of Welding Electrodes" and in presenting this subject, A.W.S. specifications on electrodes were discussed in considerable detail. The purpose of detail acquainted those in attendance with the significance of the specifications, and pointed out how these specifications serve as a guide in the selection of electrodes. A significant point which was brought out was that a welding operator who is reasonably familiar with the new A.W.S. specifications would not go very far off the track in selecting electrodes to meet the requirements of the various jobs. Considerable detail was given in describing the characteristics of electrodes falling into each class of the A.W.S. specifications, and that was the main intent of the talk.

A premeeting movie was shown entitled "The Story of A.-C. Welding," which film was produced and presented in technicolor sound by the General Electric Co.

There was a short business session during which time a nominating committee was elected from the floor for the purpose of selecting a roster of nominees for election to the executive offices of the Section.

The attendance was approximately 250, and at the conclusion of the meeting, refreshments were served in the Club Recreation Room.

SAN FRANCISCO

The principal speaker at the March 26th meeting, was LaMotte Grover, Welding Engineer for Air Reduction Sales Co., New York. Mr. Grover spoke on "Design and Construction of Arc-Welded Steel Structures," illustrating his talk with a number of very interesting slides. Some of these illustrated typical layouts for welding structures, such as bridges and building structures and, furthermore, illustrated some structures which had been thus erected. Other slides illustrated proper and improper sequences as used in ship construction. This talk evoked a considerable amount of interesting discussion.

A surprise speaker was A. G. Bissell, Principal Materials Engineer for the U. S. Navy Bureau of Ships. Mr. Bissell spoke very briefly on the "Welding Engineer."

Following the speakers, a motion picture, "Arc Welding Stainless Steel," prepared and provided by the Allegheny-Ludlum Steel Co., was presented.

WASHINGTON, D. C.

The Washington Section held its annual dinner and final meeting of the 1944–45 season on Tuesday, April 24th, at the Hotel 2400. A cocktail hour, generously sponsored by local representatives of industry, preceded the dinner, which was interrupted at strategic intervals by retiring chairman C. E. Jackson, who entertained the 106 guests from his repertoire of magic.

The organizer of the Section and first Chairman, A. G. Bissell of the Navy Department, presented "Jack" with the retiring chairman's pin. He then installed the new officers for the coming year, who are as follows: *Chairman*—S. W. Trainer, Harnischfeger Corp.; *Vice-Chairman*—G. G. Luther, Naval Research Laboratory; *Secretary*—A. Piltch, Naval Gun Factory; *Treasurer*—R. F. Wood, Washington Technical Services. *Executive Committee*—New Appointees: G. Hodge, G. B. Grable, J. O. Mack, W. M. Wilkerson. *Other Members of the Executive Committee:* C. E. Jackson, H. L. Ingram, R. H. Davies, A. G. Bissell, T. E. Haimill, R. S. Stover, J. C. Ritter, L. H. Fawcett.

Miss M. M. Kelly, *National Secretary*, was special guest of the Section and she spoke briefly of the growth of the SOCIETY and the interest of national headquarters in section affairs.

Ted B. Jefferson, Editor of *The Welding Engineer*, was the principal speaker of the evening. Mr. Jefferson discussed "Welding in the Postwar World." His material was well selected and left no doubts as to the future security of the field of welding.

The meeting closed with a lively question and answer period which was handled by the speaker.

WESTERN MICHIGAN

April meeting held on the 30th was addressed by E. B. Brown, Development Engineer of the American Brass Co., Detroit, Mich., on "Welding of Copper and Copper Alloys." Mr. Brown did a very fine job with his subject and held the interest of a sizable audience. The colored movie "Copper Goes to War" was a beautiful thing and is recommended to any audience of a welding nature.

WICHITA

The April meeting of the Wichita Section was held on the 18th. H. W. Sharp, Metallurgist, Stoody Co., Whittier, Calif., spoke on "Microstructures of Hard Facing Alloys." Mr. Sharp's talk was illustrated by interesting slides. A very active question and answer period followed.

Through the courtesy of the Army Air Forces, a sound film "Birth of the B-29" was shown.

YORK-CENTRAL PENNA.

An Annual Meeting and Dinner was held on April 11th. A delicious dinner in addition to the General Electric House of Magic were the features. This meeting was designated as Ladies Night.

YOUNGSTOWN

R. B. Lincoln of Pittsburgh Testing Labs. addressed the April 19th meeting on "Metallurgy for Welders." Sixty-five members and guests were present.

DISTRICTS AND SECTIONS—American Welding Society

(Vice-Presidents, Chairmen, Secretaries and Regular Meeting Dates)

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CHAIRMAN—PROF. P. E. KYLE, Mass. Inst. of Technology, Cambridge, Mass.
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SECRETARY—LEONARD W. COOPER, Falmouth Foreside, Town Landing, Portland, Me.

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SECRETARY—J. HOTCHKISS, 1590 Westmoreland Ave., Syracuse 10, N. Y.

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SECRETARY—E. J. PELTIER, Westinghouse Elec. Corp., 653 Page Blvd., Springfield 2, Mass.

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SECRETARY—E. C. ROWELL, 118 Oregon Ave., Portsmouth, Va.

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SECRETARY—A. PILTEN, 1445 Otis Place, N. W., Washington 10, D. C.

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CHAIRMAN—REYNOLD ALONZO, Rt. 3, Box 24, Stanton Rd., Mobile, Ala.
SECRETARY—W. E. KELLY, 1561 Luling St., Mobile, Ala.

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SECRETARY—MILTON FORMAN, 1012 Cherubusco St., Pascagoula, Miss.

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SECRETARY—G. S. HERREN, The Seagrave Corp., Columbus, Ohio

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SECRETARY—H. ROSS STROHECKER, Youngstown Welding & Eng. Co., 3700 Oakland Ave., Youngstown, Ohio

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SECRETARY—CHAUNCY HART, Heil Co., 300 W. Montana St., Milwaukee, Wis.

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SECRETARY—A. C. SLUSS, Moore Company, 556 Westport Rd., Kansas City, Mo.

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SECRETARY—J. M. MIDEKE, 100 E. Main St., Oklahoma City 2, Okla.

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SECRETARY—E. O. WILLIAMS, Victor Equipment Co., 3821 Santa Fe Ave., Los Angeles 11, Calif.

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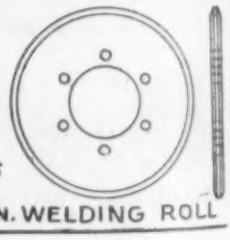

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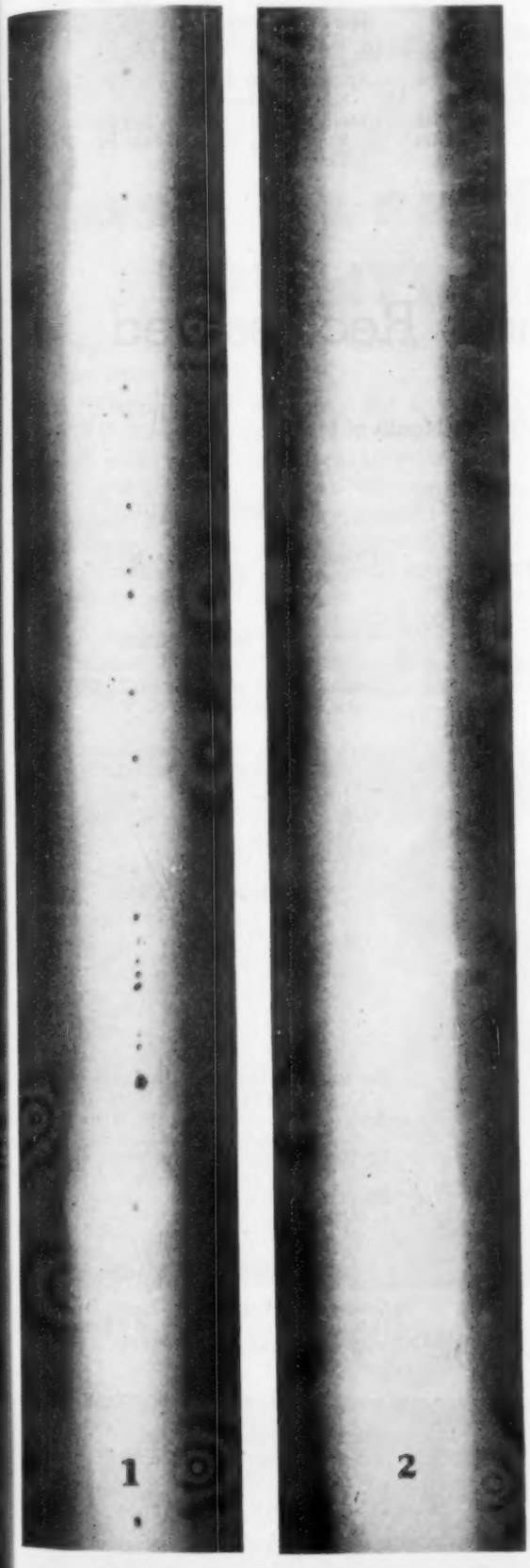
WHERE WELDS MUST BE RIGHT..Industry Depends Upon X-Ray



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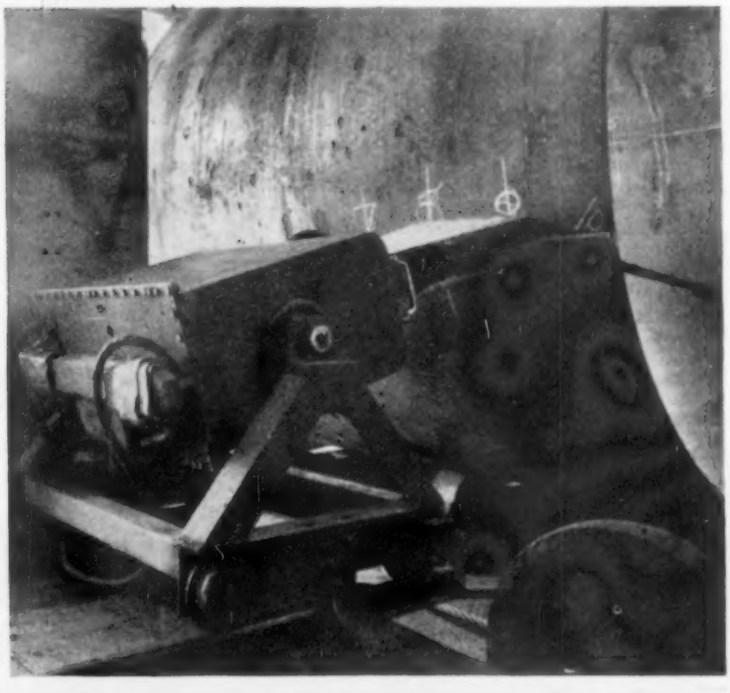

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List of New Members

March 1945

(*Continued from May issue*)

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Bair, John L. (C), R. D. 1, Bainbridge, Pa.
Baker, William H. (A), The J. E. Baker Co., 114 N. George St., York, Pa.
Broden, E. R. (B), Blaw-Knox Co., York, Pa.
Demmy, John H. (C), R. D. 1, Bainbridge, Pa.
Hebbe, G. A. (C), The J. E. Baker Co., 114 N. George St., York, Pa.
Leader, Walter I. (C), Mt. Wolf, Pa.
Sipe, N. B. (C), 30 N. Vernon St., York, Pa.

YOUNGSTOWN

Beatty, Ray F. (C), 118 N. Cedar St., Niles, Ohio.
Carter, Robert (C), Craig Beach, Lake Milton, Ohio.
Crincic, Laddie J. (C), 508 W. Princeton, Youngstown 7, Ohio.
Cumiskey, Vinc (C), Youngstown Welding & Eng. Co., 3700 Oakwood Ave., Youngstown, Ohio.
Featheringham, T. J. (B), Youngstown Welding & Engrg. Co., Youngstown, Ohio.
Harris, Calvin Clyde (C), 830 Ohio Ave., Youngstown, Ohio.
Harris, Jack C. (C), 4164 Belle Ave., Youngstown 9, Ohio.
Helsel, Clyde M. (C), Youngstown Welding & Engrg. Co., 3700 Oakwood Ave., Youngstown, Ohio.
Hillberry, Alfred D. (C), 2808 Firnley Ave., Youngstown 7, Ohio.
Holmes, Fred W. (C), 1100 Hubbard Rd., Youngstown, Ohio.
Hornickle, Forrest (C), 920 Devon Ave., Youngstown, Ohio.
Hripko, John S. (C), 4213 Rush Blvd., Youngstown 5, Ohio.
Hripko, Stephen J. (C), 162 Millet Ave., Youngstown 9, Ohio.
Hutch, Paul J. (C), 1039 Parkwood Ave., Youngstown, Ohio.
Jeswald, Joseph (C), 41 N. Meridian Rd., Youngstown 9, Ohio.
Jones, Frank Q. (C), Youngstown Welding & Engrg. Co., 3700 Oakdale Ave., Youngstown, Ohio.
Jones, Ralph M. (C), 444 Falls Ave., Youngstown, Ohio.
Masson, Donald (B), 191 Kenmore S. E., Warren, Ohio.
Means, Lloyd (C), 1318½ Hillman, Youngstown, Ohio.
Mentges, Frank (C), 511 Carroll St., Youngstown, Ohio.
McNeal, Lee (C), P. O. Box 52, Petersburg, Ohio.
Montgomery, William B. (C), 120 W. Dewey Ave., Youngstown, Ohio.
Rehbogen, John (C), 3810 Frederick St., Youngstown 9, Ohio.
Rostetter, John (C), Poland, Ohio.
Salmen, Mike, Jr. (C), 156 Cleveland St., Youngstown, Ohio.
Shank, John R., Jr. (C), North Jackson, Ohio.
Spay, Andy (C), 768 Oxford Ave., Youngstown, Ohio.
Waddell, Luther D. (C), 1034 Oakhill Ave., Youngstown 2, Ohio.
Waters, Gilbert G. (C), R. D. 2, Columbiana, Ohio.
Williams, Norman L. (C), 171 Parkgate Ave., Youngstown 9, Ohio.
Winterkamp, Frederick (B), Carnegie-Illinois Steel Corp., McDonald Mills, McDonald, Ohio.

NOT IN SECTIONS

Barker, John Thos. (C), 63 Woodcot Ave., Baildon, Yorkshire, England.
Burton, George M. (B), c/o National Cylinder Gas Co., Box 3038, Knoxville 17, Tenn.
Correa, Arnaldo (C), 19 Rector St., c/o O. Philipp Co., New York, N. Y.
Geddes, John (C), 74 Marlborough Ave., Shoreditch, London, E8, England.
Harris, Reginald Geo. (C), Rose View Wall Hill Rd., Corley Nr. Coventry, England.
Spivey, Ralph Edgar (C), USNCB, F.P.O. San Francisco, Calif.
Womble, E. (B), Lewis Supply Co., Diesel Eng. Div., 477 S. Main St., Memphis, Tenn.

Members Reclassified

During Month of March

BOSTON

Anderson, Palmer (from D to C), 105 Central St., Somerville 43, Mass.
Chapin, Wm. C. (from D to C), 167 Profile Ave., Portsmouth, N. H.
Rich, H. O., Jr. (from D to C), 191 N. Shore Rd., Revere, Mass.
Williams, John H. (from D to C), Lumsden & Van Stone Co., 426—1st St., S. Boston 27, Mass.

DETROIT

Cobb, Lee S. (from D to C), 1030 Remington Ave., Flint 3, Mich.

LOS ANGELES

Barden, S. H. (from D to C), 822 Monterey Rd., S. Pasadena, Calif.
Gray, Benjamin (from D to C), 846 E. 80th St., Los Angeles 1, Calif.
S.F.2/C Pauley, Wm. J. (from D to C), Barracks J, Navy 128, c/o F.P.O. San Francisco, Calif.
Schmidt, Wm. B. (from D to C), 642 Newport Ave., Long Beach 4, Calif.
Staninger, Earl M. (from D to C), c/o Arabian Amer. Oil Co., A.P.O. 795, c/o P.M., New York, N. Y.

MILWAUKEE

Chandler, Roy D. (from D to C), 723 Wisconsin Ave., Beloit, Wis.
Hawthorne, Wm. Jr. (from D to C), 2151 S. 85th St., W. Allis 14, Wis.

NEW JERSEY

Comandatore, Joseph (from C to B), Division Welding Co., 154 Broadway, Jersey City 6, N. J.

NEW YORK

Manzella, Joseph (from D to C), 102-30 Corona Ave., Corona, L. I., N. Y.

NORTHERN NEW YORK

Chernik, Joseph (from D to C), 21 Mynderse St., Schenectady 7, N. Y.

PHILADELPHIA

Dulis, Edward (from D to C), U. S. Navy Yard, NAF, Bldg. 600, Philadelphia 12, Pa.

PITTSBURGH

Punzo, Steve (from D to C), Box 87, Russellton, Pa.

ROCHESTER

DeCaro, Paul (from D to C), 206 Atkinson St., Rochester 8, N. Y.

SAN FRANCISCO

Stapel, A. O. (from D to C), 3600 Lincoln Ave., Oakland, Calif.

SOUTH TEXAS

Croswell, A. M. (from C to B), Southwest Fab. & Welding Co., 211—75 St., Houston 11, Tex.

TOLEDO

Baron, J. I. (from D to C), Baron Steel Co., 4075 Detroit Ave., Toledo 12, Ohio.
Bradshaw, Louis J. (from D to C), 801 N. I St., Tacoma, Wash.
Pulliam, Jesse H. (from D to C), P. O. Box 563, Keyport, Wash.
Stamm, Archie C. (from D to C), 2135 Summit St., Toledo 11, Ohio.

WESTERN MASS.

Gutowski, Walter A. (from D to C), Westfield Welding Co., 6 Clinton Ave., Westfield, Mass.

WESTERN NEW YORK

Williams, Floyd R. (from D to C), 44 Shenandoah Rd., Buffalo 20, N. Y.

NOT IN SECTIONS

Bergeson, Eric (from D to C), Platte Mach. Wks., Platte, S. D.
Berra, Albert (from D to C), Berra's Metal Shop, 413 Dougla Ave., Eveleth, Minn.
Carver, G. F. (from D to C), Longhurst, N. C.
Hansel, Lee E. (from D to C), Hansel's Body Service, Mount Holly, N. C.

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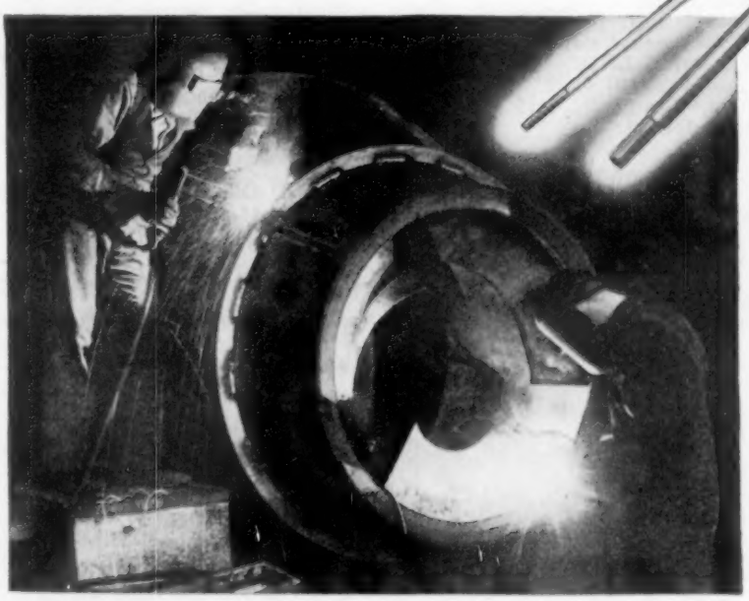

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Shaw, Richard L. (C), 67 Orchard St., Medford 55, Mass.

BRIDGEPORT

Grosberg, Harold (B), 46 Commodore Pl., Milford, Conn.

CANADA

McMulkin, Francis J. (B), Ontario Research Foundation, 43–47 Queen's Park, Toronto, Ontario, Canada.
Squire, A. J. (B), 4407 W. 15th Ave., Vancouver, B. C., Canada.

CHATTANOOGA

Thomas, C. L., Jr. (B), Ross-Meehan Fdr., 1601 Carter, c/o Steel Plant, Chattanooga, Tenn.

CHICAGO

Andrle, James Henry (C), 116 W. Maple Ave., Roselle, Ill.
Greenlee, Fred W. (B), Metal & Thermit Corp., 151st St. & McCook Ave., E. Chicago, Ind.
Wood, Kenneth A. (B), Metal & Thermit Corp., 7300 S. Chicago Ave., Chicago, Ill.

CINCINNATI

Burdett, R. W. (B), 5915 Red Bank Rd., Cincinnati 27, Ohio.
Kemp, C. Eugene (B), Hamilton Welding & Mfg. Co., 121 N. B St., Hamilton, Ohio.
Telford, George W. (C), 6882 Esther Lane, Madeira, Ohio.
Schultz, William P. (C), Ralston Steel Car Co., 2901 E. Fourth Ave., Columbus, Ohio.
Vonville, A. O. (C), Ralston Steel Car Co., 2901 E. Fourth Ave., Columbus, Ohio.

DETROIT

Butler, Arthur R. (B), Welding Equip. & Supply Co., 223 Leib St., Detroit 7, Mich.
Butler, Harry (B), Welding Equip. & Supply Co., 223 Leib St., Detroit 7, Mich.
Chew, Lawrence (C), 1114 Fudd Ct., Flint, Mich.
Crampton, Carl (C), 2006 Kentucky Ave., Flint 6, Mich.
Kessler, Frank E. (B), Welding Equip. & Supply Co., 223 Leib St., Detroit 7, Mich.
Miltimore, Charles R. (B), Welding Equip. & Supply Co., 223 Leib St., Detroit 7, Mich.
Scott, P. D. (B), Welding Equip. & Supply Co., 223 Leib St., Detroit 7, Mich.
Zanolli, A. R. (B), Welding Equip. & Supply Co., 223 Leib St., Detroit 7, Mich.

INDIANA

Campbell, J. W. (C), 915 Washington Blvd., Anderson, Ind.
Culbertson, Russell P. (C), 2217 N. Waugh St., Kokomo, Ind.

LOS ANGELES

Carroll, Andrew S. (C), 3105 Dorchester Ave., Los Angeles 32, Calif.
De Van, Ralph W. (C), 3644 Walnut St., Lynwood, Calif.
Kennedy, Frank J. (C), 332 Redondo Ave., Long Beach 4, Calif.
Kuntz, Paul J. (C), Air Technical Service Command, Attn. Service Station, Inspt. Div., 3636 Beverly Blvd., Los Angeles, Calif.
Muldoon, James J. (C), U. S. Maritime Commission Inspec. Office, c/o Calship, Wilmington, Calif.
Rash, Berl D. (C), 115 E. 61st, Los Angeles 3, Calif.
Sorensen, Clark H. (C), 615 S. Marguerita Ave., Alhambra, Calif.
Stewart, Darrel L. (C), 1736 W. 51st St., Los Angeles 37, Calif.
Whitmore, Glenn (C), 1415 Delta St., Rosemead, Calif.

LOUISVILLE

Adams, E. L. (C), Glyn Adams Welding Co., 216 S. Shelly, Louisville, Ky.
Glyn, R. L. (C), 629 Cecil, Louisville 12, Ky.
McLean, Chester (C), 707 Headly Ave., Lexington, Ky.

MARYLAND

Brewer, Harry S. (C), 5901 Arabia Ave., Baltimore 14, Md.
Craig, John C. (C), 5701 Pope St., Brooklyn 25, Md.
Konopik, Frederick J. (C), 1602 Church St., Baltimore 26, Md.

MICHIANA

Howe, Ralph E. (C), 1001 Evergreen Lane, South Bend, Ind.

NEW JERSEY

De Muth, Joseph, Jr. (C), Welding Supply Co., 65 Van Riper Ave., E. Paterson, N. J.
Sexton, Daniel E. (C), 38 May St., Newark, N. J.

NEW YORK

Batchler, Carl V. (B), 311 W. 21st St., New York, N. Y.
Haydock, John (B), McGraw-Hill Publishing Co., 330 W. 42nd St., New York 18, N. Y.
Jonassen, Finn (B), War Metallurgy Committee, 92 Liberty St., Rm. 1505, New York 6, N. Y.
Osterholz, John F. (B), 68-11 Fresh Pond Rd., Brooklyn 27, N. Y.
Schiff, Leonard S. (F), c/o Trageser Copper Wks., Inc., 5000 Grand Ave., Maspeth, N. Y.
Stiso, Michael (C), 2649 Decatur Ave., Bronx, N. Y.

NORTHWEST

Lamey, Leo (C), 987 Bayless Ave., St. Paul 4, Minn.
Harrison, Gordon (C), 1777 Princeton, St. Paul 5, Minn.
Mattson, Everett L. (C), Y.M.C.A., Duluth 2, Minn.
Prestegaard, Paul G. (C), 138 Westwood Dr., Tyrol Hills, Mpls. 5, Minn.

PASCAGOULA

Burns, William V. C), 1323 11th St., Pascagoula, Miss.
Johnson, Walter C. (C), Ingalls Shipbldg. Corp., Pascagoula, Miss.
McLaughlin, Harry P. (B), c/o Ingalls Shipbldg. Co., Pascagoula, Miss.
Montgomery, Warren J. (C), Box 1202, Eastlawn, Pascagoula, Miss.
Pelan, W. D. (C), The Ingalls Shipbldg. Corp., P.O. Box 149, Pascagoula, Miss.
Simmons, Benjamin (C), 358 Herrick St., Pascagoula, Miss.

PEARL HARBOR

Hoopal, Olney K. (C), 834 Judd St., Route 44, Honolulu, T. H.

PEORIA

Deemy, George A. (C), 400 Margaret, Peoria, Ill.
Walker, Mark M. (C), 623 Sherman St., Peoria, Ill.
Warren, Lawrence W. (C), 431 S. Main St., Decatur 22, Ill.

PHILADELPHIA

Fairless, Victor C. (B), c/o Susquehanna Pipe Line Co., Honey Brook, R.F.D. 1, Pa.
Hendrickson, Dan F. (C), 7214 Alder Brook Rd., Upper Darby, Pa.
Landesberg, Arnold L. (B), 6120 Webster St., Philadelphia 43, Pa.
Rush, David (B), Fly Wheel Welding Service, 1308 Poplar St., Philadelphia 23, Pa.

PITTSBURGH

Crawford, William D. (B), Duquesne Light Co. 435 Sixth Ave., Pittsburgh 19, Pa.
Haupin, Warren E. (C), Aluminum Club, New Kensington, Pa.

PORTLAND, ME.

Tibbitts, Erban (C), 35 St. Lawrence St., Portland, Me.

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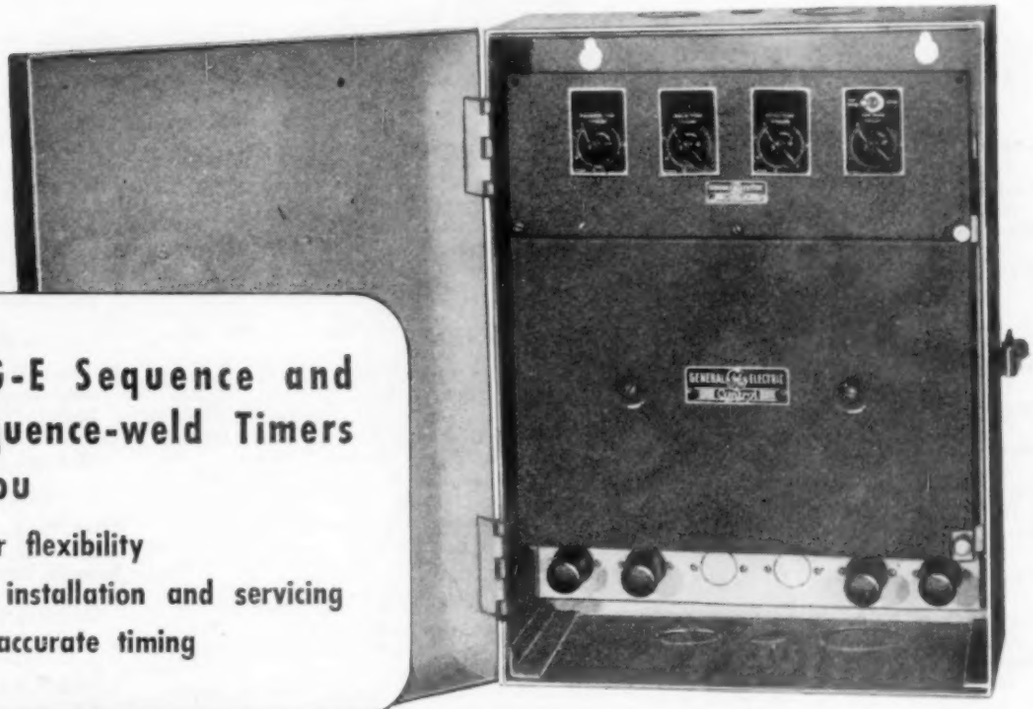

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O'Brien, Paul M. (C), 748 Culver Rd., Rochester 9, N. Y.

ST. LOUIS

MacIntyre, Robert K. (B), 719 Euclid Ave., Alton, Ill.

SAN FRANCISCO

Charles, Oval L. (C), 919 Grant St., Vallejo, Calif.
Danton, Walter B. (C), 25 States St., Apt. 4, San Francisco 14, Calif.
Mason, Fred J. (B), 3857—35th Ave., Oakland 2, Calif.
Wran, Gilbert Warren (B), 3949—39th Ave., Oakland 2, Calif.

TACOMA

Anderson, Andrew (B), 4131 North Gove, Tacoma, Wash.
Anglea, John D. (B), Route 9, Box 235, Tacoma, Wash.
Bartley, L. W. (C), 1115½ S. 11th, Tacoma, Wash.
Berry, Alva A. (C), 6512 Sylvan Way, Apt. 607, Seattle 6, Wash.
Berry, Robert J. (C), 1652 E. 29th, Tacoma Wash.
Bohlander, Alfred A. (C), Rt. 1, Box 540A, Puyallup, Wash.
Bolton, Donald F. (C), 364 Auburn Ave., Salishan, Tacoma 5, Wash.
Brawn, Jack (B), Route 13, Box 199D, Tacoma, Wash.
Brinson, C. C. (C), R. R., 1, Box 568, Puyallup, Wash.
Brown, Merritt H. (B), 3707 N. 21st St., Tacoma 7, Wash.
Butcher, W. C. (B), 4821 S. D., Tacoma, Wash.
Cole, Stanley D. (C), 415½ S. 4th, Tacoma 3, Wash.
Charest, R. V. (C), 29 St. Helens Ave., Tacoma 3, Wash.
Crain, Eugene R. (B), Route 7, Box 752B, Tacoma, Wash.
Dachyk, Herman (B), Rt. 2, Box 2, Tacoma, Wash.
Davis, U.S.N.R., Lieut. Bernard W. (C), 704 N. Stadium Way, Tacoma, Wash.
Davis, James R. (C), 2502 S. Melrose St., Tacoma 6, Wash.
De Tienne, Cecil E. (B), 3702 S. Ainsworth, Tacoma, Wash.
Draughon, R. D. (B), 502 E. 96th, Tacoma, Wash.
Eichorst, Harvey C. (B), 610 S. Stevens, Tacoma, Wash.
Enstrom, Walter R. (C), 2810 E. E St., Tacoma 2, Wash.
Faste, Andreas A. P. (B), Route 6, Box 145F, Tacoma, Wash.
Fox, Otis I. (C), P.O. Box 217, Milton, Wash.
Garstad, Ray R. (B), 1014 S. Jay St., Tacoma, Wash.
Christensen, Homer Granville (B), 5802 S. Fife, Tacoma, Wash.
Glandon, Glenn W. (B), P.O. Box 1534, Tacoma, Wash.
Gregg, Charles T. (C), 3631 E. Eye, Tacoma 4, Wash.
Gretler, J. Floyd (C), Route 8, Box 602A, Tacoma, Wash.
Hill, Arnold C. (C), 2104 S. 40th, Tacoma, Wash.
Irons, Frederick Wheeler (C), 8632 S. D St., Tacoma 4, Wash.
Jacobson, Harold B. (B), 1202 N. Prospect, Tacoma 6, Wash.
Kenworthy, Thomas M. (B), 100 Dayton Ave., Tacoma, Wash.
Lachambre, James (B), 2915 E. B St., Tacoma, Wash.
McKeen, K. W. (C), Route 2, Box 496, Tacoma, Wash.
Melby, Earl V. (C), 801 N. Eye St., Tacoma, Wash.
Moe, Edwin E. (C), 4119 N. 15th St., Tacoma 6, Wash.
Moore, Wm. L. (B), 2801 N. Union Ave., Tacoma 7, Wash.
Moline, Raymond E. (C), Box 169, Route 1, Graham, Wash.
Musgrove, Marvin N. (B), 1208 S. 46th, Tacoma, Wash.
Nicholas, James (C), 115 S. 48th St., Tacoma 8, Wash.
Nixon, Hugh R. (B), 5444½ S. M St., Tacoma, Wash.
Olson, Kenneth E. (B), 1430 Washington St., Sumner, Wash.
Olson, William (C), 1801 E. Morton, Tacoma, Wash.
Oman, Frank (B), Route 1, Box 370A, Gig Harbor, Wash.
Pattee, John H. (C), Route 1, Box 169, Puyallup, Wash.
Salinger, Frederick Laurens (C), Supervisor of Shipbldg., U.S.N., Todd-Pacific Shipbldg. Co., Tacoma 2, Wash.
Schumann, Arvine L. (B), 124 Auburn Ave., Salishan, Tacoma 5, Wash.
Sheehan, Emmet K. (C), 215 E. 72nd St., Tacoma 4, Wash.
Smith, William C. (C), 5002 S. L St., Tacoma 8, Wash.
Sonneson, A. E. (B), P.O. Box 114, Enumclaw, Wash.
Southworth, Alvin A. (C), Route 9, Box 595, Tacoma, Wash.
Stinson, Del. (C), 4918 S. G St., Tacoma 8, Wash.
Strommer, Henry O. (C), 722 W. State St., Aberdeen, Wash.
Stroope, George D. (C), 1442 E. 34th St., Tacoma, Wash.
Turner, Frank C. (B), 1209 S. Gee 3, Tacoma, Wash.
Vohs, William (C), 1008 S. 12th St., Tacoma, Wash.
Walter, George F. (B), 5843 Pacific Ave., Tacoma 8, Wash.
Welton, Walter J. (C), Todd-Pacific Corp., Alexander St., Tacoma, Wash.
Willis, Jack N. (B), 662 Findlay St., Seattle 8, Wash.
Wright, James (B), 3815 Pacific Ave., Tacoma 8, Wash.
Yergenson, Don R. (C), 309 E. 32nd, Tacoma, Wash.

TULSA

Davenport, Floyd D. (B), Maloney Tank Mfg. Co., Plant 2, Tulsa, Okla.
Gannaway, Chas., Jr. (B), Tulsa Boiler & Mach. Co., 2020 S. Union St., Tulsa, Okla.
Holmberg, J. C. (B), Tulsa Boiler & Mach. Co., 2020 S. Union St., Tulsa, Okla.
McIlhiney, James G. (C), P.O. Box 590, Tulsa, Okla.
Rooney, Hugh (B), Tulsa Boiler & Mach. Co., 2020 S. Union St., Tulsa, Okla.

TIDEWATER

Collier, James C. (C), 1609 Des Moines Ave., Portsmouth, Va.
Metzka, Andrew (C), 4310 Quail St., Sewalls Garden, Norfolk 2, Va.
White, Lewis M. (B), 1307 Center Ave., Norfolk 2, Va.

WESTERN MASS.

Brown, Fred L. (B), 190 New Bridge St., W. Springfield, Mass.

WESTERN MICH.

Priest, Harold M. (B), The Motor Shop Priest Tool Co., 103 South Ave., Battle Creek, Mich.

WESTERN NEW YORK

Repman, Russell E. (B), Morrison Metalweld Process, Inc., 1437 Bailey Ave., Buffalo 12, N. Y.
Zentecki, Alex K. (C), Y.M.C.A., 45 W. Mohawk St., Buffalo 2, N. Y.

YORK-CENTRAL PENNA.

Riley, J. J. (C), Riley Welding Service, R.R. 112, York St., Hanover, Pa.
Roberts, Ernest (B), Cardiff, Md.
Sterner, George (B), Red Lion Cabinet Co., Red Lion, Pa.

YOUNGSTOWN

Kezell, Felix S. (B), R.D. 3, Beaver Falls, Pa.
Roth, Albert, Jr. (B), Mackenzie Muffler Co., West Side Post Office, Youngstown 9, Ohio.

NOT IN SECTIONS

Holman, Arnold C. (B), R. 2, Fairchild, Wis.
Lamph, John I. (B), Jacks Body & Fender Shop, 44 N. Merchant St., American Fork, Utah.
Pickett, James Patrick (C), Ths. Heiton & Co., Ltd., 37 Georges Quay, Dublin, Eire.
Raffensberger, Russell M. (C), Amer. Inst. of Steel Const., Inc., 506 Jefferson Standard Bldg., Greensboro, N. C.
Tame, Charles Wm. (B), 1 Suderoft St., Canton, Cardiff, South Wales, Great Britain.
Zeigler, Wm. L. (C), 4023 Rawlins St., Dallas, Tex.

Members Reclassified

During the month of April

BOSTON

Barnett, Carleton E. (from D to C), Eastman Barnett Co., 162 Binney St., Cambridge 42, Mass.
Perry, Domingo F. (from D to C), 4 Carlton St., R.F.D. 4, New Bedford, Mass.

CHICAGO

Porter, Delbert D. (from D to C), 3901 Wisconsin Ave., Berwyn, Ill.

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Isgrigg, Raymond (from D to C), 112-14-15 S. 10th St., Louisville 2, Ky.

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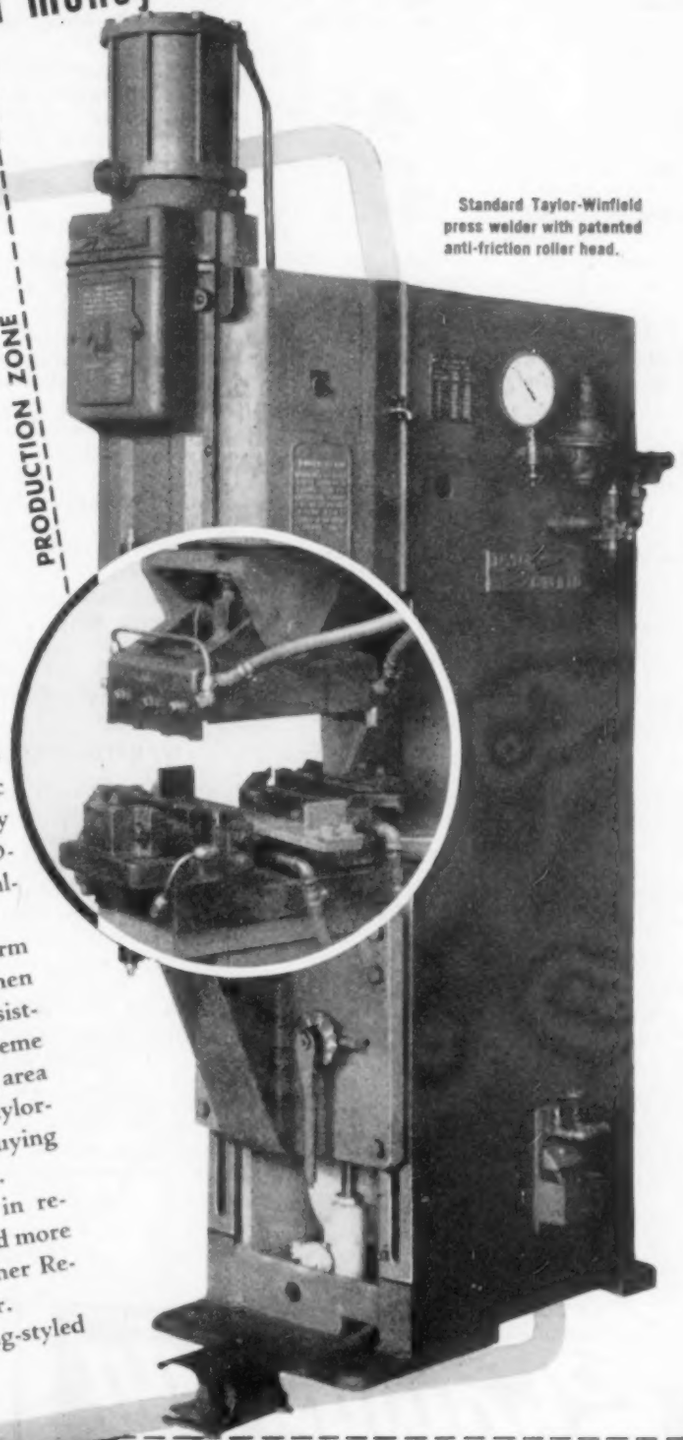

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A 12-page brochure, covering the object and purpose of the Award Program for Textbooks in Modern Design and setting forth all rules and conditions governing the program, has just been published by trustees of The James F. Lincoln Arc Welding Foundation, Cleveland, Ohio.

The brochure is the official document of the new Award Program as announced by the Foundation in April to encourage preparation of Textbooks on design for use of engineering undergraduates in machine design and in structural design for fabrication by all processes including welding. It thoroughly covers the types of subject matter to be treated in these two important fields, listing the awards which are divided into the two classes and which total $20,000.

The attractively printed pamphlet carries such explanatory paragraphs as those dealing with royalties for manuscripts of award-winning authors, method of payment of awards, eligibility requirements, bases of judgment in rating papers, how to present subject matter and other pertinent facts designed toass ist prospective participants.

The brochure, entitled, "$20,000 Award Program for Textbooks Covering Machine and Structural Design for Modern Processes Including Welding," may be obtained gratis by anyone interested. Requests should be addressed, Secretary, The James F. Lincoln Arc Welding Foundation, Cleveland 1, Ohio.

ELECTRONICS BOOKLET

Walker-Jimieson, Radio & Electronic Distributors at 311 South Western Ave., in Chicago, have just published a new edition of their "Industrial Availability Booklet" which shows items available on priority for immediate delivery from stock. This latest edition which consists of 48 pages lists tubes, test equipment, industrial sound equipment, electrica maintenance supplies, timers, relays, x ra machines, constant voltage transformers, rectifiers, demagnetizers, tachometers, etchers, dynamotors, conductivity apparatus, condensers, resistors, flashlight storage batteries, pencil soldering irons, industrial switches, electric drills, saws, grinders and other tools available *from stock*. Walker-Jimieson offers to send this monthly free to any engineers or purchasing agents requesting it.

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